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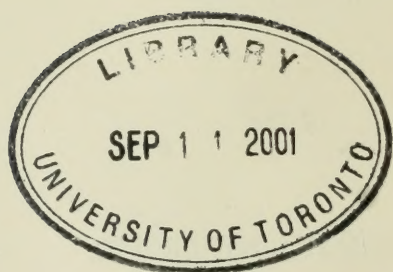
DEPARTMENT of
EXPERIMENTAL
SURGERY

of the

NEW YORK UNIVERSITY
and BELLEVUE HOSPITAL
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Contributors to Vol. III of the Department of Experimental Surgery under the Department of Surgery, New York University and Bellevue Hospital Medical College.

GEORGE DAVID STEWART, M.D., LL.D., F.A.C.S.

(Professor of Surgery, New York University and Bellevue Hospital Medical College, and Director of the Third Surgical Division, Bellevue Hospital.)

WILLIAM CHITTENDEN LUSK, M.D., F.A.C.S.

(Professor of Clinical Surgery and Assistant Surgeon, Bellevue Hospital.)

CHARLES GOODMAN, M.D., F.A.C.S.

(Clinical Professor of Surgery.)

WILLIAM HOWARD BARBER, A.B., M.D., F.A.C.S.

(Lecturer on Surgery and in Charge of Department of Experimental Surgery, Assistant Surgeon, Bellevue Hospital.)

LOUIS CHARLES LANGE, M.D.

(Lecturer on Surgery and Assistant in Charge of Department of Operative Surgery.)

HARRY BELLEVILLE EISBERG, M.D.

(Instructor on Surgery and Assistant in Charge of Department of Experimental Surgery, Adjunct Surgeon, Bellevue and Allied Hospitals.)

EDWARD MEAKIN LIVINGSTON, B.S., M.D.

(Instructor on Surgery and Adjunct Surgeon, Bellevue Hospital.)

LUIGI CELANO, M.D.

(Instructor on Surgery and on Pathology, Pathologist for the Third Surgical Division, Bellevue Hospital.)

ALEXANDER FOSCHEE, M.D.

(Anaesthetist for the Third Surgical Division, Bellevue Hospital.)

CONSTANTINE L. A. ODEN, M.S., M.D.

(Formerly Senior House Surgeon, Bellevue Hospital.)

JOHN TOLIVER

(Technician, Department of Experimental Surgery.)

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Further observations upon reflex gastric hypermotility.

By **W. HOWARD BARBER** and **GEORGE D. STEWART**

*[From the Department of Surgery, New York University and Bellevue
Hospital Medical College.]*

Increase in the force or rate or change in the direction of gastric contractions have followed irritation of the gallbladder, duodenum, or appendix, experimentally, and these motor changes have been associated with pathological gallbladders, duodenums, and appendices, clinically.¹ It may be assumed, subject to further experimental proof, that these organs constitute three of the possible foci of reflex gastric stimulation. Were the nerve paths known along which these impulses travel, it might be possible to explain these motor responses and group other possible causes of gastric motor unrest.

Other observations of abnormal reflex gastric activity in which the pyloric and fundic parts functionate separately are the following:

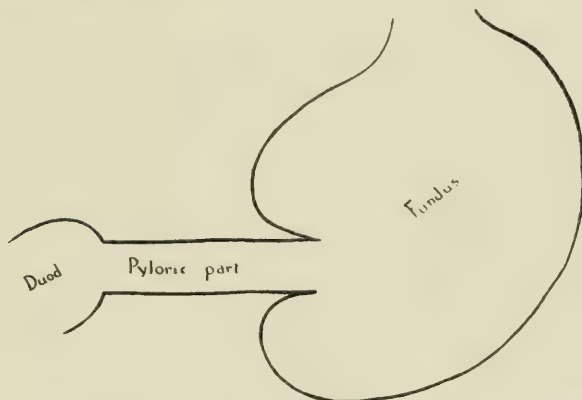
1. Prostalsis of the pars pylorica, alone, occurring in the course of irritation of the above organs and after thoracic vagus section.
2. Anastalsis of the pars pylorica, alone, associated with traumatization of the gallbladder.
3. Pro- and anastalsis of the pars pylorica, alone, after extra-gastric traumata before the stomach appears to settle down to definite rhythmical contractions and is produced mechanically by dividing or blocking the stomach at the junction of the pyloric part and the fundus. It also follows thoracic division of the vagi.
4. Pylorospasm, diffuse, with fundic relaxation resembling a pylorofundic intussusception (see diagram).

This fourth type has been observed repeatedly under experimental traumatization of the gallbladder, duodenum, or appendix

¹ PROCEEDINGS SOC. EXP. BIOL. AND MED., Vol. XVI., No. 7.

and once in the human with evidence of appendical and gall-bladder disease. It can be produced by direct stimulation of the lesser curvature at the junction of the descending and horizontal arms. The subjective evidence, associated with this motor state, is anorexia, vomiting, and epigastric pain. The objective signs are mass and tenderness over the stomach, present at times and absent at other times. This form of motility, as appears to be the rule with the reflex types, disappears with parietal peritoneal irritation.

Experimental data, to date, indicate the total hypermotility to be of probable vagus and the pyloric hyperactivity, alone, to be of probable vago-sympathetic origin.



SCHEMATIC REPRESENTATION OF DIFFUSE PYLORIC SPASM AND FUNDIC RELAXATION RESEMBLING A PYLORO-FUNDIC INTUSSUSCEPTION.

ANNALS OF SURGERY

227 South Sixth Street, Philadelphia, Penna.

MARCH, 1922.

**ACUTE PERFORATED ULCER OF THE STOMACH
OR DUODENUM**BY **GEORGE DAVID STEWART, M.D.**

AND

WILLIAM HOWARD BARBER, M.D.

OF NEW YORK, N. Y.

FROM THE DEPARTMENT OF SURGERY, NEW YORK UNIVERSITY AND BELLEVUE HOSPITAL MEDICAL COLLEGE

ACUTE rupture of the stomach or duodenum is generally recognized as a serious surgical indication for immediate hospital attention. The treatment received after admission varies with the operative methods of the respective surgeons under whose care the cases are placed. Twenty-four cases were admitted under the department of surgery during the past five years, *all* of which were operated upon by some one of six members of the attending staff by the simple practice of inversion and drainage. The fact that these operators, of varying ages and experience, used the same method for gastro-duodenal perforation and secured uniform results lends additional weight to the value of the method. Of these patients, with the single exceptions of one two-day and one three-day ruptures, all survived. These results give an operability for acute perforation of ninety-two, an operative mortality of none, and a total mortality of 8 per cent. No case was denied the chances of operative recovery even if the probability of survival were against him. Very good results have been reported by others on selected cases by the combined method of inversion and gastro-enterostomy. It is the purpose of this study to present the above cases in outline together with the rationale of inversion, only, for perforation.

The ages, sexes, and nationalities of the respective patients appear on the accompanying table. Aside from these possible predisposing factors of ulcers, no further observations will be noted at this time on the etiology of ulcer.

The location of these ulcers is represented diagrammatically by the dark shading for the most frequent site of occurrence and by the light lines for less common sites, see Fig. 1. All but one are found on the anterior surfaces of the oral one and a half inches of the duodenum and pyloric end of the stomach and 76 per cent. at the anatomical pylorus or within a distance of two inches of the sphincter. The one posterior rupture appears on the first part of the duodenum. The size of the callosity varies from a palpable hardening to an involvement of the whole pylorus and adjacent gastric and duodenal walls; the perforations from that of a pin's head to one and a half centimetres in diameter. Often the typical findings are the abnormal amount and alimentary character of the free fluid and gas within the peritoneal cavity and the evidence of irritation caused by contact of the stomach's contents with

the peritoneum. Occasionally a high-pitched blowing sound is encountered upon opening the belly. This hissing sound, due to the stomach's driving of gas and fluid through the rupture, varies with the size of the opening and with the tone of the stomach. The extent of soiling and the degree of peritonitis vary with the size of the perforation, the contents of the stomach, the motility of the stomach, and the length of time elapsed after rupture. Occasionally with small ruptures along the lesser curvature and on the posterior wall the contamination is taken care of by adhesive formation which converts an otherwise acute break into a subacute or chronic perforating

Table Covering the Acute Perforations of the Stomach or Duodenum Admitted and Operated upon during the past Five Years (1914-1919.)

No.	Name	Date Adm.	Age	Sex	Nationality	Duration of Prev. Hist.	No. Hrs. Elapsed	Surg.	Result
1	R. W.	4-29-14	26	F.	Russian	2 wks.	6	S.	Cure
2	I. N.	5-12-14	35	M.	Russian	8 yrs.	4	C.	Cure
3	T. O.	2-10-15	39	M.	Italian	2 wks.	48	S.	Fatal
4	M. S.	7-21-17	37	M.	Italian	?	2	S.	Cure
5	B. K.	1-3-17	28	F.	Irish	?	24	F.	Cure
6	R. H.	3-17-17	24	M.	U. S.	?	4	S.	Cure
7	J. C.	3-26-17	42	M.	U. S.	?	72	W.	Fatal
8	A. C.	3-29-17	27	F.	U. S.	3 yrs.	7	W.	Cure
9	R. B.	3-31-17	37	M.	Irish	?	22	S.	Cure
10	L. W.	6-4-17	27	M.	U. S.	1 wk.	8	W.	Cure
11	M. S.	7-10-17	45	M.	Austrian	?	6	D.	Cure
12	C. O.	8-25-17	46	M.	Sweden	2½ yrs.	24	H.	Cure
13	F. O'C.	9-22-17	36	M.	Irish	4 wks.	6	D.	Cure
14	M. B.	8-31-17	51	F.	Irish	?	?	S.	Cure
15	M. G.	10-19-17	?	M.	Hebrew	?	3	S.	Cure
16	P. H.	1-5-18	55	M.	Irish	?	6	S.	Cure
17	P. C.	11-24-18	54	M.	Irish	?	6	S.	Cure
18	R. G.	2-20-18	?	M.	Italian	?	4	C.	Cure
19	R. M.	6-15-18	24	M.	U. S.	5 yrs.	2	B.	Cure
20	C. P.	12-7-18	30	M.	?	2 yrs.	3	B.	Cure
21	H. H.	12-9-18	25	M.	Russian	2 mos.	5	B.	Cure
22	L. P.	3-25-18	31	M.	U. S.	5 yrs.	12	B.	Cure
23	W. G.	6-8-18	19	M.	U. S.	2 wks.	8	B.	Cure
24	M. H.	6-17-19	23	M.	U. S.	0	6	B.	Cure

NOTE.—The letters S., D., W., F., and B., designate the operators: Stewart, Douglas, Cramp, Wadhams Foskitt, and Barber, respectively.

ulcer. The liver, gastrohepatic omentum, pancreas, and rarely the transverse colon have been found in such instances the important barriers against free soiling. The frequency of concealed perforation represented by some is not borne out by the statistics of Symmers from the autopsy records of Bellevue Hospital. In this series, excluding two moribund cases of forty-eight and seventy-two hours, respectively, three individuals present themselves between twenty and thirty hours after rupture and the remaining nineteen before twenty hours, making an average of eight hours. In most instances the colon bacillus has been recovered from the peritoneum, in one individual, six hours after the onset of the acute pain, which probably marked the occurrence of the pyloric rupture. The streptococcus and staphylococcus have been less frequently found. Although the colon organism has

been recovered from the presumably normal stomach, experimentally, it is probably true that the peritonitis met with in the earliest hospital cases is non-infectious.

The pathology explains the sudden onset of agonizing upper abdominal pain with prostration, the board-like rigidity and exquisite tenderness, the hissing sound, if present, of gastric emptying through the rupture, and the polyneucleosis. It is important to observe the sudden onset of dyspnoea, the rapid costal breathing, and the sharp pain whenever the diaphragm is thrown in. Pneumonia, pleurisy, tabes, gastric dilation, gastroduodenitis, the lead colics, etc., should be excluded. Other conditions which have presented themselves for differentiation are influenza, pneumococcus peritonitis,



FIG. 1.—Diagram representing by dark and light shading the more and less frequent locations of perforated ulcers of the stomach and duodenum.

acute hemorrhagic pancreatitis, perforative cholecystitis, ruptured appendicitis, and mesenteric thrombosis.

Influenza, occurring during the fall and winter, may present extreme abdominal pain and rigidity while the local tenderness does not remain as definitely epigastric. Distinguishing points should appear in the history. One individual, complaining of pain in the lower left quadrant and presenting rigidity and tenderness in the upper right quadrant, disclosed, at operation, a thin sero-fibrinous exudate on the hepatic flexure and leaves of the mesosigmoid and developed broncho-pneumonia two days post-operative.

Pneumococcus peritonitis occurred in one instance in an adolescent male without history and without signs of lung involvement either before or after operation. There were sudden onset of abdominal pain, vomiting, and generalized peritonitis. In this particular case the "terminal ileum contained lymph follicles which stood out visibly and lymph-nodes in the mesentery of the terminal ileum, measuring 2 to 5 cm. in longest diameters." The pneumococcus was recovered from the exudate and from the appendix. Recovery followed appendectomy.

In acute hemorrhagic pancreatitis, the individual resembles the gall-bladder type of patient and often gives a history and symptoms suggestive of cholecystitis. The pain is severe, the tenderness epigastric and right lumbar, and both are far out of proportion to the rigidity, which is not very marked.

Perforative cholecystitis in the early hours is characteristic of gall-bladder disease, when general peritonitis has developed it may be impossible of differentiation. The same is true of acute appendicitis which should be suggested before peritoneal involvement by appendical skin hyperalgesia.

Mesenteric thrombosis occurred once in the hospital series in a Bohemian of forty, who gave a history of abdominal pain and vomiting for one day and generalized tenderness and rigidity. Operation revealed obstruction well up in the mesenteric vessels and total gangrene of the small gut. In this instance the rigidity was marked, but the most tender point appeared to be below the umbilicus.

The operative methods recommended, include excision, inversion, gastro-enterostomy, pyloric occlusion, and combinations of these. Excision and pyloric occlusion are of theoretical interest only; inversion with or without gastro-enterostomy is the operation of choice.

In the present series inversion and drainage, with or without plication and omental grafting, have been the rule of practice. Gastro-enterostomy was not performed in a single case. This treatment is as follows: Each perforation upon entering the surgical ward is gone over by the house staff and prepared for immediate operation. Urine, blood, and blood-pressure are examined and, after diagnosis, morphia is administered to allay shock. In the proper cases transfusion is arranged for. The incision is upper right rectus; in the doubtful cases an opening may be made at the umbilicus and enlarged upward or downward as the indications warrant. To further combat shock, the intra-abdominal work is made as speedy and as accurate as possible and all peritoneal traumata are kept at the minimum. Cleansing of the peritoneum is accomplished by removing with forceps any coarse food particles that may be present and by aspirating the surplus fluid with a sucker. The stomach and duodenum are mobilized by holding conveniently in moist gauze pads while the ulceration is inverted by one or more purse-strings or by interrupted Lemberts of chromic gut. In the extensively indurated ulcers, the duodenum is freely plicated over the pyloric end of the stomach. When practicable, the omentum is tacked over the site of inversion. Drainage is based upon the extent of peritoneal soiling; *in situ* cigarette drains are used in every case, upper right lumbar drains through stab wounds in selected cases, and, in the majority of individuals, additional pelvic drains are left in the lower angles of the abdominal wounds. In the one exception in which no drainage at all was instituted, the patient poured out excretions from between the sutures. Cultures are taken, and all wounds are closed in layers with interrupted sutures.



FIG. 2.—Control, one day after ether anaesthesia and laparotomy. Note distended stomach and duodenal cap. (Exp. No. 25.)

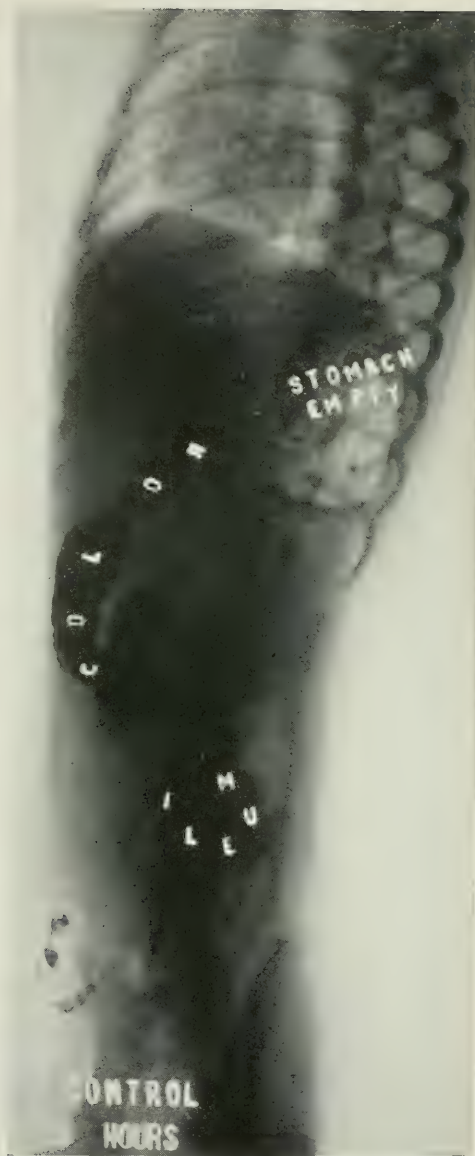


FIG. 3.—Control one day after ether anaesthesia and laparotomy. Note—Stomach empty 5 hours after bismut meal with head of column in colon and tail in ileum.

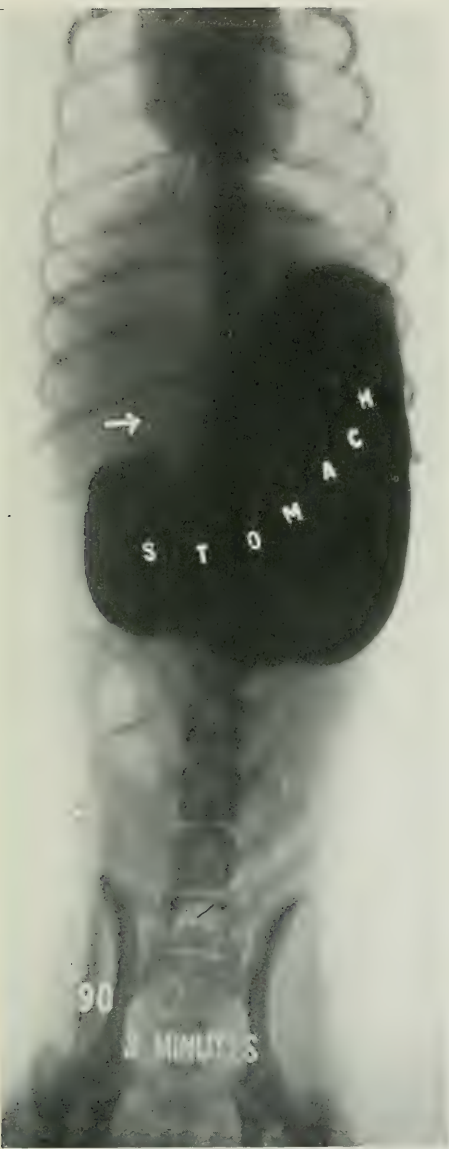


FIG. 4.—Pyloric perforation 3 days post-operative. Note stomach and obstructed "cap." (Exp. No. 90.)

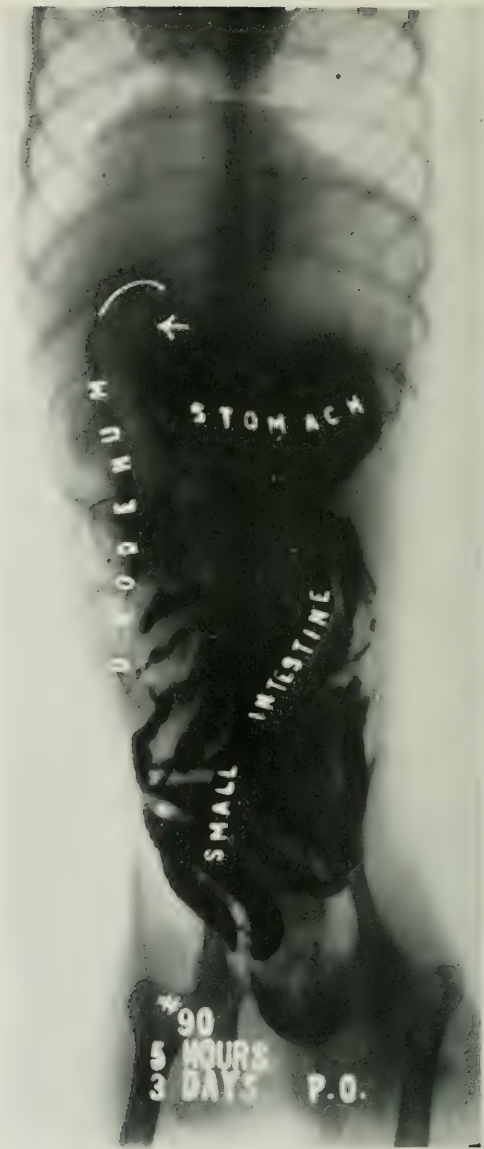


FIG. 5.—Pyloric perforation 3 days post-operative. Note—5 hours after bismuth meal; residue in stomach, duodenum and small intestine; head of column in sigmoid (not labeled on print but seen lying caudad of mass of small intestine).

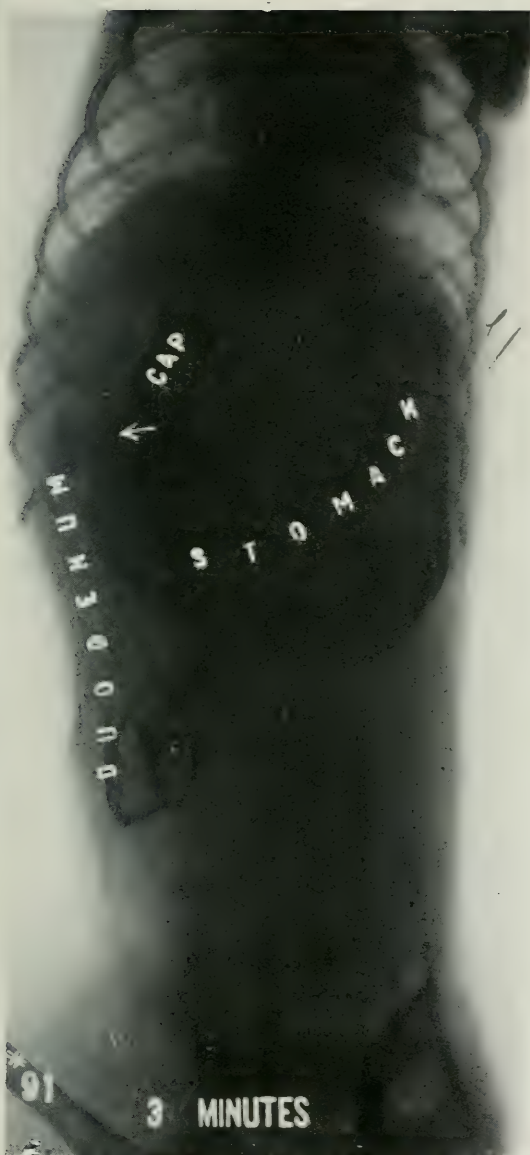


FIG. 6.—Pyloric perforation 4 days post-operative. Note—stomach obstructed "cap" and duodenal filling. (Exp. No. 91.)

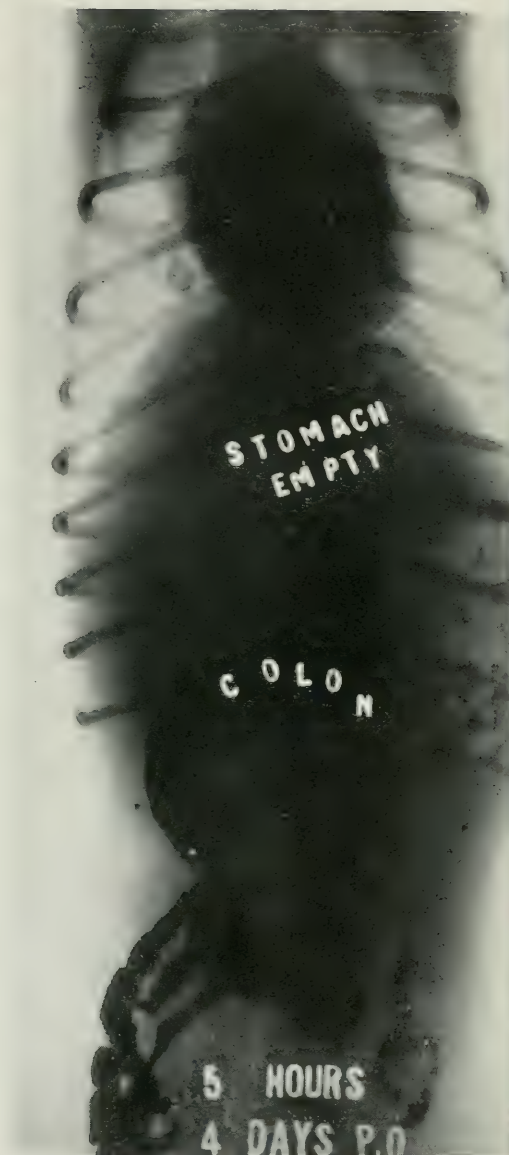


FIG. 7.—Pyloric perforation 4 days post-operative. Not 5 hours after bismuth meal, empty stomach; column with head in descending colon and tail in ileum. (Exp. No. 91.)



FIG. 8.—Microphotograph of healing 3 day perforation. Epithelium (A) is beginning to bridge in gap between edges of wound. Note fibrous plug of scar tissue (B).

The post-operative care is that of peritonitis. Most patients are placed in the Fowler position; selected cases are left prone or in the head-down position, depending upon the location and extent of peritoneal soiling. Fluids are supplied by rectum. Patients are kept warm by external heat and quiet by the use of morphia, if necessary, for the first forty-eight hours. The time of feeding depends upon the patient's desire for food, for the onset of the patient's hunger contractions seems to be the most dependable guide. Most of these crave water, which is given on the third day. Albumin water and milk are given in increasing quantities on the succeeding days until a fairly generous ulcer-diet is allowed at the end of three weeks. By this time the patients are up and about the wards ready for discharge to a convalescent ward, if possible, for by this means the diet and general care of the patient may be supervised for five to seven weeks, or, if this cannot be arranged, the convalescents are discharged under instructions to report for periodic observations in the follow-up clinic.

The complications in this series have been diaphragmatic pleurisy in one case, acute pneumonic phthisis in another, and delayed wound-healing requiring secondary suture in another. Every case was given a chance of operation including the two- and three-day cases, one of which, in spite of transfusion, died upon the operating table and the other soon after returning to the ward. All the remaining of the twenty-four cases recovered uneventfully.

The follow-up care of these patients has consisted, as far as possible, in keeping them under observation or in getting them to report by answer to questionnaire on their conditions. An analysis of replies covering the past one- to five-year cases shows that in most instances these people have returned to their former habits and occupations and that they consider themselves cured or satisfactorily improved. There is occasionally pyloric impairment enough to give a six-hour residue. There are "occasionally gas disturbances," "occasionally gas and pain," and in two instances "vomiting occasionally." Of these vomiting cases, one gained fifteen pounds and the other twenty pounds in weight. One individual who reported "occasional pain" and a gain in weight of sixteen pounds volunteered the information that he had pain "only after overeating." These reports compare favorably with the chronic ulcer cases upon whom gastro-enterostomies have been performed.

This method of treatment is two-fold; namely, that of the acute patient first brought into the hospital and that of the discharged patient during observation. The indications of the acute stage are taken to be closure of the perforation and drainage; those of the discharged patient, the possible appearance of surgical obstruction of the pylorus. To date there has been no secondary treatment, not because all the patients have been entirely symptom-free, but because no one patient would acknowledge that he was sufficiently uncomfortable to allow himself to be reoperated upon. This

experience corresponds with Gibson's New York cases and with the twenty post-operatives followed by Wright in Stewart's St. Vincent's cases.

The rationale of simple inversion for perforation as opposed to inversion with gastrojejunostomy is further borne out on the experimental stomach. Pyloric stenosis, present at the time of operation or thought likely to appear thereafter, is taken as the indication for anastomosis. Obstruction at the pylorus is believed of frequent occurrence after a plastic of the kind above described, but it is thought to be transitory in nature and to have largely disappeared by the time of onset of hunger contractions. To illustrate the repair of a perforation at the pylorus and the return of the pyloric canal to normal function after inversion, plication, and grafting, the stomachs of five dogs were perforated, closed, X-rayed, and sectioned.

Experimental Technic: The pyloric sphincter of each of five dogs is perforated by means of a cautery iron and closed by inversion by means of two purse-string sutures, by plication of the duodenum across the anterior face of the pyloric end of the stomach, and by tacking the available omentum over the site of the inversion. In order to eliminate the gastric inhibition due to the ether anæsthesia and laparotomy, a control-animal was anæsthetized and a laparotomy performed exactly as in the case of each of the other animals but nothing whatever was done within the abdomen. The animal was given water by rectum and nothing by mouth as were all the animals. Each dog was given a 300 c.c. zoolack-bismuth emulsion and X-rayed for outline and emptying time. The control was X-rayed after one day, the perforations on the first to fifth days post-operative. After radiographing each of the five inversions, the stomach was removed, photographed, and the specimen microphotographed.

It is to be emphasized from the above technic that closure of the perforation is carried out so as to give the animal the maximum of protection against possible leakage without any idea of preventing pyloric obstruction. Under these conditions, clinically, pyloric stenosis might be considered probable and, for that reason, gastro-enterostomy might be indicated.

The behavior of these experimental stomachs corresponds with the clinical courses of human cases.

Röntgenological Findings: (Based upon radiographs by L. T. Le Wald, q. v. 2-7.) Stomachs distended with opaque meal in all. Hypermotility accounting for spontaneous initial emptying. Pylorospasm recorded in all the animals. Filling defects in pyloric portions or in duodeni of all, due to spasms or deformities. Five-hour retention in one-, two- and three-day dogs and complete emptying in four- and five-day animals. Control shows active motile pyloric part, "cap," and total clearance within the five-hour interval. The progress of the bismuth columns in the remaining intestinal tracts may be seen in part on the accompanying röntgenograms.

From the X-ray standpoint the normal stomach may be expected to empty under the above experimental conditions in three and one-half hours, the stomach one day after an abdominal wound and anæsthetic shows retrostalsis (vomiting) and a one-hour delay, stomachs with obstructed pyloric outlets, as above described, develop hypermotility, including pylorospasms, during the first three days and hypermotility without obstructing spasms on the fourth and fifth days post-operative.

That this delay is, in part, purposeful or protective, appears from the gross and microscopical pathology (*Cf.* 8 and 9-13, author's notes).

Surgical Pathology (gross): Approximately six hours after the bismuth meals the stomachs of all five animals were examined. All appear fairly well contracted. The distorted pyloric ends and duodeni appear very much as left at operations but this distortion seems to have been somewhat overcome by a straightening out of the stomachs in the fourth- and fifth-day animals. After opening the stomachs the tips of the little fingers could be passed through the pyloric canals of the fourth- and fifth-day stomachs, but not through those one to three days post-operative. These findings correspond with the infolding which appears more evident during the first three days. The perforative wounds are tight and amply protected (microscopical). Fraser found the inverted edges in close contact in all, œdematous swelling in the one- to three-day specimens, and fibrous bridging and epithelialization in the later sections. (*Fig. 8.*)

It is believed that the letting-up of the gross mechanical obstruction, the microscopical repair, the disappearance of obstructive pyloric spasms, and the return of hunger contractions as early as the fourth and fifth days, emphasize the transiency of the stenosis resulting from inversion and plication.

SUMMARY

(1) This report is based upon twenty-four acute perforated ulcers of the stomach and duodenum coming under the department of surgery during the last five years.

(2) All were given a chance of operative recovery and with the single exceptions of one three-day and one two-day perforations all survived. The operative procedure in each instance was inversion and drainage with or without plication and omental grafting.

(3) Gastro-enterostomy has not to date appeared indicated in the subsequent courses of these patients. The rationale of inversion appears further borne out by a study of the surgical pathology of perforation in the normal stomach.

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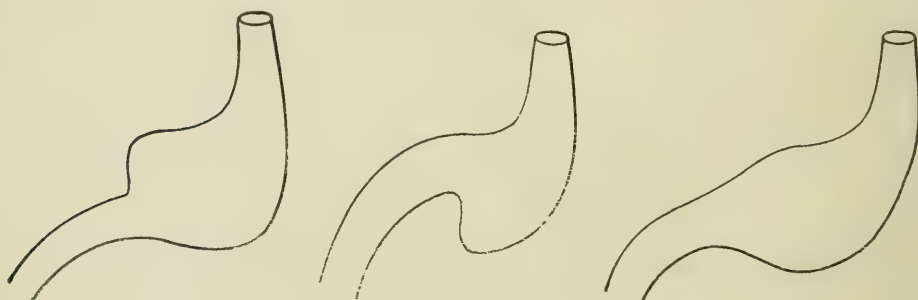
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I. Gastric resection: experimental data on the duodenal loop

By **W. HOWARD BARBER** and **LOUIS C. LANGE**.

[*From the Department of Experimental Surgery, New York University and Bellevue Hospital Medical College.*]

Operable new growths and malignant ulcers require in selected cases resection of the pyloric end of the stomach. After resection, the surgeon is forced to meet the problem of gastroenterostomy. Taking for granted the removal of the greater portion of the pyloric end of the stomach, continuity of the gastroenteric canal may be re-established by any one of the following methods as suggested in the following diagrams:

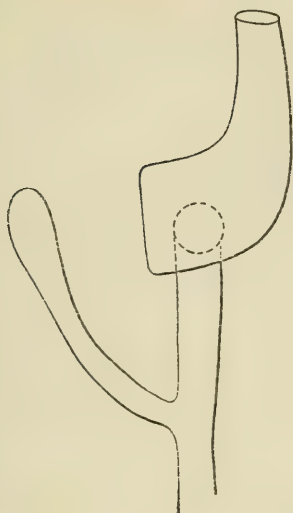


A

B

C

Terminal Gastroduodenal Anastomosis.



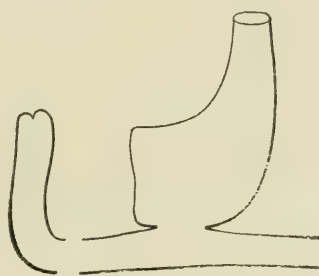
D
Lateroterminal Gastrojejunal
Anastomosis.



E
Terminolateral Gastrojejunal
Anastomosis.



F



G

Lateral Gastrojejunal Anastomosis.

Compatible with life.

Terminal methods, *A, B, C.*

Lateral, *F.*

Incompatible with life.

Lateroterminal, *D.*

Terminolateral, *E.*

Lateral, *G.*

Lethal Factor-Pancreatic Injury.

Types of gastroenteric anastomosis following partial gastrectomy.

These experiments have been performed upon dogs without mortality in the method of terminal gastroduodenostomy and with high mortality in those methods involving duodenal occlusion or duodenostomy.

II. Gastric resection: notes on the surgical pathology.

By W. HOWARD BARBER and LUIGI CELANO.

[From the Department of Experimental Surgery, New York
University and Bellevue Hospital Medical College.]

Terminal anastomosis between the divided ends of the stomach and jejunum, as represented in Part I, Fig. D, combined with duodenal occlusion and implantation of the duodenal loop into the jejunum caudad of the stomach gives the following results:

Exp. No.	Days of Life.	Pathology.
69	4	Peritonitis.
77	2	Pancreatitis.
82	3	Pancreatitis.
83	2	Peritonitis.
84	3	Pancreatitis.
85	2	Pancreatitis.
91	1	Pancreatitis.

GASTRIC RESECTION.

289

Lateral anastomosis *without resection* but with occlusions of the pyloric end of the stomach and duodenum Fig. G show the following results:

Exp. No.	Days of Life.	Pathology.
201	2	Pancreatitis, superficial necrosis and erosions in stomach and in testine about stoma.
207	3	Necrosis similar to but earlier than in 201.
219	1	Pancreatitis.

Lateral anastomosis combined with simple ligation in first portion of duodenum:

Exps. 86 and 87 after 6 and 2 days, respectively, pancreatitis.

Lateral anastomosis without resection but with pyloric occlusion and duodenostomy, Fig. F:

Exp. No.	Days of Life.	Pathology.
204	5	Pancreatitis.
205	4	Pancreatitis.
209	2	Pancreatitis; hydropneumothorax.
210	3	Pancreatitis.
211	14	Malnutrition.
213	14	Ulcer, gastrojejunal.

In the above experiments, mobilization of the extreme oral end of the duodenum in the dog sufficient for closure and inversion of that end is invariably followed by fatality of evident pancreatic origin. Of six duodenostomies, four give evidence of pancreatitis and two (211, 213) show extreme emaciation on fourteenth days.

Note: In the above tables, the term pancreatitis has been used to designate the complex found in the clinical cases: fat necrosis, free hæmolyzed blood in the peritoneal cavity and often in the intestinal loops, and evidences of pancreatic injury from congestion and cloudy swelling to suppuration.

ENTEROPARESIS

W. HOWARD BARBER, M.D.

Assistant Attending Surgeon, Bellevue Hospital

NEW YORK

ENTEROPARESIS *

W. HOWARD BARBER, M.D.

Assistant Attending Surgeon, Bellevue Hospital

NEW YORK

According to the nomenclature of the Bellevue and Allied Hospitals,¹ the term "intestinal neurosis" includes "enteroparesis" and "enterospasm," while "intestinal obstruction" is applied only to mechanical obstruction. Thus, adynamic or paralytic ileus and dynamic or spasmodic obstruction are included under neuroses of the intestine. Ileus, derived from the Greek *ελαίν*, to twist,² was originally applied to the ileum because the ileac loop was most often obstructed. The term ileus is defined as severe colic or acute abdominal pain associated with intestinal obstruction, although by some of us the absence of pain is held to characterize the paralytic type of ileus. It is suggested that the grouping of all mechanical obstructions under "intestinal obstruction," the functional nervous types of disturbed bowel motility under "neuroses," and the obstructions of vascular origin under "thrombosis, etc., of the mesenteric vessels" simply and accurately classifies the more common forms of clinical intestinal obstruction.

Enteroparesis resembles acute dilatation of the stomach and the condition of shock from the standpoint of external cause and symptoms, and it may be that these three conditions are not greatly unlike, physiologically or pathologically. Traumas may give rise to dilatations of the stomach and bowel and to shock, especially such traumas as occur during operations on the abdomen. Either acute dilatation of the

* From the Department of Surgery, University and Bellevue Hospital Medical College, Prof. George D. Stewart, director.

* Read before the Section on Gastro-Enterology and Proctology at the Seventy-Third Annual Session of the American Medical Association, St. Louis, May, 1922.

1. The Bellevue Hospital Nomenclature of Diseases and Conditions, 1911.

2. Dorland, W. A. N.: The American Illustrated Medical Dictionary, Philadelphia, W. B. Saunders Company.

stomach or enteroparesis may occur alone;³ or these two conditions may appear together; or gastric dilatation and paralytic ileus may comprise a part of the syndrome recognized as shock. That shock may occur without either paresis of the stomach or of the bowel seems evident to any one who has seen and operated on a patient with acute perforated ulcer of the stomach.

The temperature in this condition of enteroparesis may be normal, above normal or below normal. The pulse and respiration may be rapid, depending on the severity of the condition. The periphery is cold and pale. The pupils may be dilated, the facial expression distressed, and gulping or emesis may be frequent. Pain may be a distinguishing symptom in intestinal paresis, due to stomach cramp; but this symptom disappears when the stomach dilates. The vomiting of paralytic ileus may be projectile and provokable by the taking of even small amounts of water by mouth. In paralysis of the stomach and bowel, the dilated stomach fills out the upper abdomen, gastric peristalsis does not occur, and from time to time there is an overflow of stomach contents from out of the mouth. From these acute dilatations of the stomach and bowel, enterospasm differs in that there is very likely to be acute pain localized in the region of the spasm. Enterospasm, like gastrospasm, may be due to local disease or may be a pathologic reflex from some other organ. All these functional conditions are definite diseased conditions that, unabated, go on to kill the patient and, therefore, demand prompt investigation into the cause of the obstruction followed by the institution of rational treatment, if the patient is to be saved.

Enteroparesis may follow mechanical obstruction of the bowel, or interference with the circulation of the intestine,⁴ or it may be associated with infection and toxemia. There undoubtedly are many possible reflex causes of bowel paralysis. Murphy⁵ included in his classification strangulation of the omentum, hepatic and renal calculi, ovarian compression, and pleuritic

3. Reinhard (*Deutsch. Ztschr. f. Chir.*, February, 1922) disagrees with the author on this point and holds that "acute dilatation of the stomach is always combined with atony or paralysis of the upper bowel."

4. Barker (*Contributions to Medical and Surgical Research*, July 12, 1919, p. 319) cites the ileus syndrome after mesenteric arterial sclerosis, and Carlyle (personal communication to the author) holds that enteroparesis is the rule after arteriosclerosis of the mesenteric vessels.

5. Murphy, J. B.: *Clinics*, August, 1914, p. 621.

and diaphragmatic irritation. Case 1 of the present group presents, among other possible etiologic factors, an omental anchorage band across a loop of large bowel; Case 3 is instructive from a reflex point of view in that following acute perforation of the urinary bladder and mechanical obstruction of the ileum there is acute suppression of urine. Braun and Legueu⁶ have reported instances of acute paralysis of the stomach following ureteral catheterization.

Our own experiments have indicated a relationship between gastric tone and renal trauma. It may be that under certain conditions, stimuli from the kidney arrest the bowel function and stimuli from the bowel check kidney function. We have been studying the motility of the stomach in our gallbladder cases,⁷ and are in hope that a typical gallbladder stomach may eventually be described that will supplement our present means of diagnosing gallbladder disease.

Cannon⁸ has shown splanchnic inhibition following the crushing of the testicles, and Pottenger⁹ has brought out the frequency of viscerovisceral reflexes between the lung and stomach. Other possible reflex causes of paralytic ileus are particularly parietal and visceral peritoneal traumas, such as occur during operations. Contractions have been repeatedly observed in the open abdomen under experimental and clinical conditions until the irritation from handling or from instrumentation reflexly inhibits these movements. It is found that simply rubbing the index finger over the peritoneum at the margin of the abdominal wound often promptly checks peristalsis. Our anesthetist, Dr. Foschee, at Bellevue, has observed that frequently changing the position of the retractors depresses the patient under anesthetic (Fig. 1). Bayliss and Starling¹⁰ thus express their findings on this point:

The splanchnics bear tonic inhibitory impulses to the intestine. These are accentuated by reflex inhibition of local origin. . . . The most striking method of producing reflex

6. Braun and Legueu, cited by von Nieden: *Arch. f. klin. Chir.*, Nov. 17, 1921.

7. Stewart, G. D., and Barber, W. H.: *The Gastric Hypermotility Associated with Diseases of the Gallbladder, Duodenum and Appendix*, *J. A. M. A.* **73**: 1817-1820 (Dec. 13) 1919.

8. Cannon, W. B.: *Am. J. Physiol.* **30**: 118-127, 1912; **6**: 252, 1902.

9. Pottenger: *Symptoms of Visceral Disease*. St. Louis, C. V. Mosby Company, 1919.

10. Bayliss and Starling: *Am. J. Physiol.* **24**: 99, 1909.

inhibition is stimulation of the intestine itself. If one or both splanchnics be intact, the slightest stimulus applied to the intestine, even a gentle handling of the intestine, suffices to produce a reflex inhibition of the whole length of the intestine.

Mall¹¹ holds that the inhibitory influence of the splanchnics is superfluous, for the intestine acts without connections of the spinal nerves. There can be no doubt, in view of the investigations on the subject, that the alimentary tube possesses an autonomy, but that in a normal intact animal the stomach and intestine remain responsive to influences from either a vagal visceromotor or a splanchnic visceroinhibitory system of nerves.

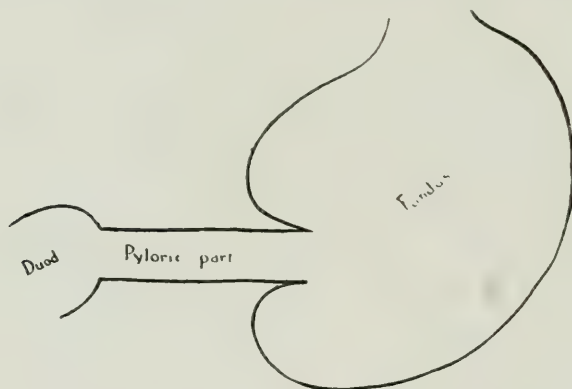


Fig. 1. — Schematic representation of diffuse pyloric spasm and fundal relaxation resembling a pylorofundal intussusception (from a case reported in *Proc. Soc. Exper. Biol. & Med.* **82**: 1542 [April 21] 1920). The symptoms were anorexia, vomiting, epigastric pain; mass, and tenderness. The condition, believed to be essentially of central vagus origin, disappeared immediately following irritation of the parietal peritoneum at the edges of the abdominal wound. This condition of diffuse pylorospasm and reversed peristalsis can be produced experimentally by clamping the pyloric sphincter, an observation which suggests the pylorus as the source of such impulses clinically, as in pyloric ulcer, cholecystitis and appendicitis.

In the depressed states manifested as bowel or stomach paralysis or in shock, there presumably is injury of nervous tissue. The vagus nerves may be conceived as being affected in these states directly by impulses which depress, or indirectly by inhibiting impulses conveyed through the sympathetic fibers. The pneumogastrics are essentially involved in respira-

11. Mall: *Johns Hopkins' Hosp. Rep.* **1**: 37, 1896.

tion, circulation and alimentation, and these three functions particularly suffer. The rapid superficial breathing, the rapid weak pulse, and the dilated alimentary tract may very well follow interference with normal vagus control (Figs. 2, 3 and 4). The influence of severe head and bodily injuries and diseases on the medullary centers may theoretically work in this way. Experiments have been carried out on the vagi in the cervical regions with very little trauma and without interfering with the abdomen at all. This is impossible as far as the thoracolumbar fibers are concerned. After section of the left vagus or the right vagus or

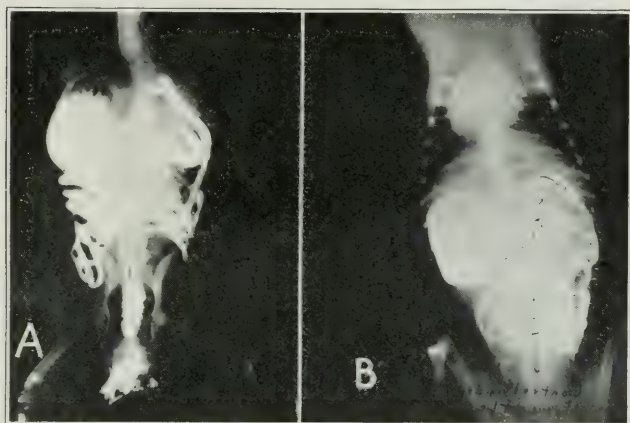


Fig. 2.—*A*, control before stimulation of cervical vagus; *B*, control after stimulation experiments were concluded.

of both tenth nerves at the same time in the same animal, the bismuth meal is seen to pass along the alimentary tube at the same rate of time as was observed in the same animals before section. The myenteric and segmentation reflexes remain intact as in the normal individual (Fig. 5). In the parietic state the intestine dilates, and the intrinsic reflexes are lost.

The observations made in the anesthetized animal through the open abdomen during stimulation of the vagus have been hypertonicity of stomach and intestine characterized by spasm and forcible peristalsis. Fig-

ures 2, 3 and 4 represent the conscious animal exposed to the roentgen rays while being stimulated by the galvanic current through the cervical vagus. Pylorospasm and duodenospasm appear under these conditions and at the time the pictures were taken without any appreciable changes in the tension of the stomach as a whole or in the mass of intestine.

It has been suggested that the handling of the organs impairs the neuromusculature and the plexuses of Meissner and Auerbach, which would apply to the traumas of abdominal operations but to only a part of the total cases of stomach and bowel paralysis.

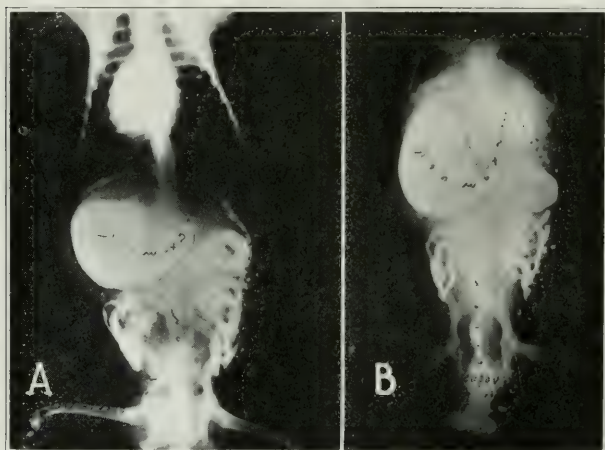


Fig. 3.—Stomach and intestine during stimulation of *A*, right and *B*, left vagus, respectively.

Jackson¹² suggests that action on the extrinsic nerves either through vagus depression or through splanchnic stimulation may initiate paralytic ileus by (1) dilating the viscera, (2) obliterating the capillaries, and (3) impairing the elasticity of the smooth muscle. From this point on, the intestine fails to contract even after the restoration of normal extrinsic nerve balance, until the status of the neuromusculature again becomes normal. In instances of marked dilatation unrelieved for from forty-eight to seventy-two hours, spots of gangrene may develop along the

12. Jackson, H. C.: Personal communication to the author.

antimesenteric border of the obstructed loops. These areas of necrosis have been well described by Van Buren.¹³ Personal experiments¹⁴ agree with those of Cannon¹⁵ and of Parham,¹⁶ and the experience of Novak¹⁷ in showing the paralyzing influence of stretching on smooth muscle.

The loss of extrinsic nerve control in these dilated bowel conditions is further borne out in the experience of those working in splanchnic nerve anesthesia.



Fig. 4.—Stomach and intestine during stimulation of both vagi.

Perrier,¹⁸ using the technic of Kappis, reports failure by himself and others in the ileus cases which he attributes to the “weight of the heavy loops of bowel.”

The sharp bends and twists in the dilated loops of bowel and the finding of adhesions about damaged intestine have led to the selection of these characteristics as mechanical causes of obstruction in “ileus”

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- 13. Van Buren, F. C.: *Ann. Surg.* **72**: 610-615, 1920.
 - 14. Barber, W. H.: *Ann. Surg.* **69**: 271-277 (March) 1919.
 - 15. Cannon, W. B.: *Am. J. Physiol.* **29**: 264-265, 1911.
 - 16. Parham, F.: *Texas State J. Med.*, November, 1915.
 - 17. Novak, Emil: *Acute Postoperative Dilatation of the Stomach*, *J. A. M. A.* **77**: 81 (July 9) 1921.
 - 18. Perrier, C.: *Rev. méd. de la Suisse Rom.* **41**: 355 (June) 1921.

cases. I am inclined to ascribe these findings to overcrowding, and the adhesions to attempts at repair. The kinking at the pylorus in dilated stomach has perhaps attracted most attention, and has been described to be the cause of gastrectasia. Similarly, those interested in intestinal "stasis" have been prone to blame the flexures of the colon for the delay in the bowel contents in these cases, although impaction of feces immediately orad of these sites of bowel suspension must be very rare.¹⁹ (See observation on

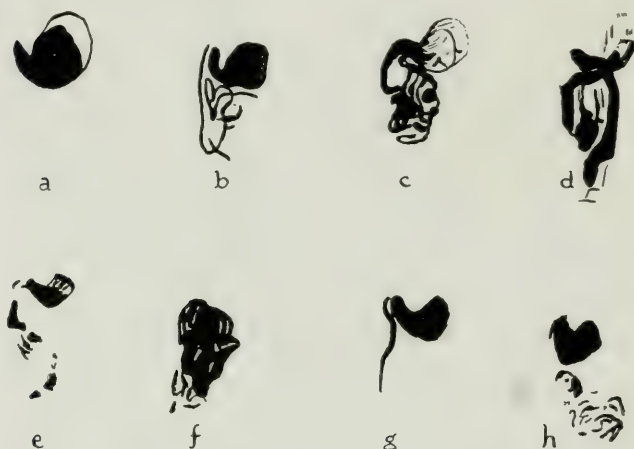


Fig. 5.—Tracings of roentgenograms of dogs before and after vagus section: *a*, stomach five minutes after meal in animal with right vagus in neck severed; *e*, same animal four hours later; *b*, stomach and intestine fifteen minutes after meal in animal after section of left vagus in neck; *d*, same, four hours later; *c*, control of *d*; *f*, control of *e*; *g* and *h*, after division of both vagi, ten minutes and four hours, respectively, after meal.

splenic flexure of Case 1.) All these possible causal factors occur in peritoneal tuberculosis, in which obstruction is not only very uncommon, but diarrhea is the rule. It is probable that these angulations, twists and bands act as contributory etiologic agents along with senility and constitutional disease in the production of enteroparesis.

If we accept as a working hypothesis extrinsic nerve irritation, either vagus depression or sympathetic stimulation, in a susceptible individual, combined

19. Professor Senior of the department of anatomy has not found in his experience that there is any diminution in the lumen of the flexures, as compared with that of the remaining colon.

with local neuromuscular depression to explain the mechanism of enteroparesis, it follows that the treatment in such cases must be directed toward the support of the general health and nervous equilibrium of the patient and toward the relief of the overdis-

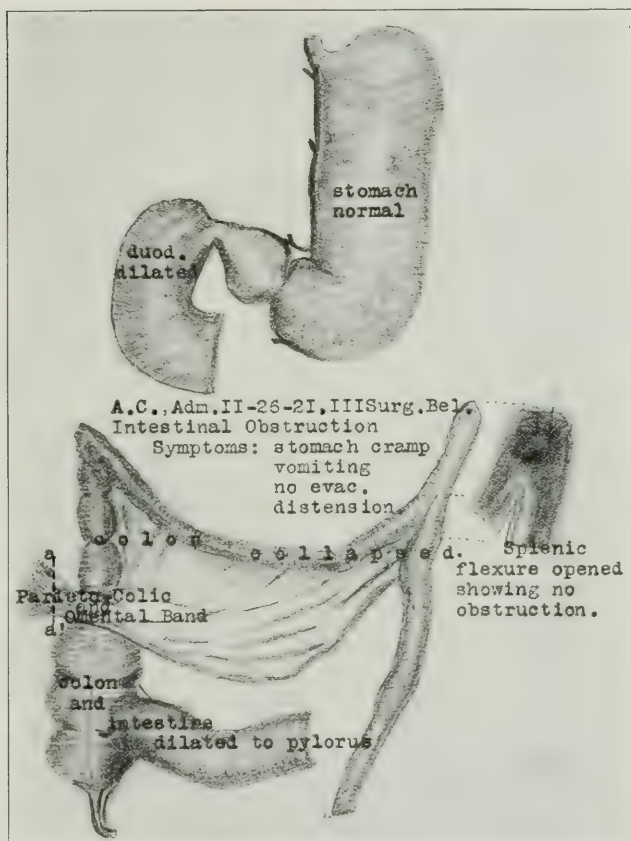


Fig. 6 (Case 1).—Release of band *a-a'* allowed escape of gas to splenic flexure, and in less amount into descending colon. Cecopexy was performed; cecostomy was not necessary. Necropsy confirmed the foregoing and revealed arteriosclerosis and fatty heart.

tended bowel. Physostigmin (eserin), atropin and pituitary extract may be tried. Lavage and enemas should be administered and, if these are ineffectual, ileostomy should be performed.

PROTOCOLS

CASE 1.—C. A., a woman, aged 55, Italian, who entered the third surgical division, Bellevue Hospital, Nov. 25, 1921, had fallen down a flight of stairs and had broken her arm the preceding day. On admission, she complained of epigastric

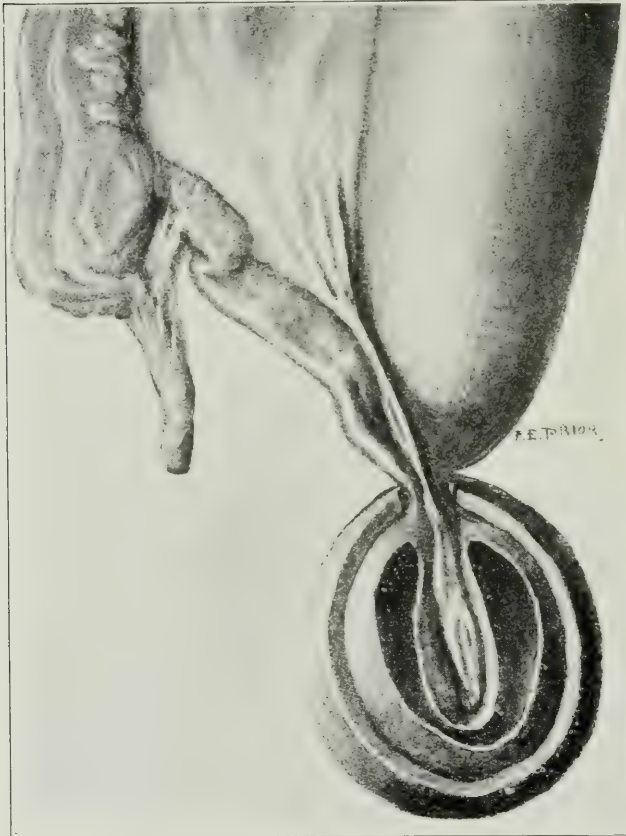


Fig. 7 (Case 3).—Semidiagrammatic drawing of intestinal obstruction produced by the passage of the ileum into the urinary bladder through a perforated fundal ulcer.

pain, vomiting, and inability to move the bowels. The pain was associated with visible peristalsis, and remained localized in the epigastrium. The vomiting was projectile, and was provoked by the swallowing of small amounts of fluid. The distention of the abdomen was moderate in degree, and at

no time during the patient's stay in the hospital did it become a threatening factor. The temperature remained normal or one degree above, the pulse averaged 100, and the respirations from 20 to 30. The periphery was pale but fairly warm, excepting during the last day, when the patient became blanched and cold. She showed in her expression evidence of extreme intra-abdominal pain; and it was this outstanding feature that compelled operation. The patient was operated on, November 29. The findings were: stomach, normal; bowel from the pyloric sphincter to the middle of the ascending colon, dilated; remaining colon, collapsed; an old adhesion, made up in part of parieto-colic membrane and in part of great omentum across the middle of the ascending colon distal to the dilated bowel, and a sharply angulated splenic flexure through which gas could be made to pass with great difficulty. The contents of the dilated bowel were gaseous. The significant findings were the normal stomach associated with dilated bowel, which began abruptly at the pyloric sphincter and ended mysteriously in the ascending colon. The adhesion was divided, the cecum was fixed to the abdominal wall so that cecostomy could later be performed if desired, and the abdomen was closed. Water was given by hypodermoclysis and by rectal infusion. Gastric lavage was carried out repeatedly. Morphin was administered and external heat kept up. November 30, after a temporary improvement, death followed sudden cardiac collapse. Post-mortem examination revealed a fatty heart weighing 360 gm., with slight endocarditis and coronary sclerosis, atheroma of the aorta, small arteriosclerotic kidneys weighing 220 gm., a small congested spleen, a small multilobular liver, and a gastro-intestinal condition as noted at operation. The splenic flexure was opened and a large baggy opening was found, the exact opposite condition one would infer from the sharp pointed flexure seen in the open abdomen. The dilatation of the small and first part of the large intestine remained as described at operation, notwithstanding the division of the omental band.

To be noted in this case are: (1) peripheral trauma; (2) constitutional impairment of essential organs, and (3) bowel paralysis; (4) the outstanding symptom, pain, and (5) the large baggy splenic flexure, which appeared sharp and obstructive. The trauma and organic disease are believed to have brought on the paralytic ileus and toxemia that brought on the patient's death.

CASE 2.—J. P., a woman, aged 30, Italian, developed an acutely distended abdomen five days after an enterocolostomy. While the patient lay comatose in her bed, the wound was reopened and a catheter sutured into the first dilated loop of

small bowel that appeared. Relief through discharge of gas and fluid was followed by recovery.

Ileostomy restored the patient by relieving the dilated bowel, while the intestinal tone remained intact. This experience is probably typical of a small proportion of the postoperative ileus cases in which relief is not given by lavage, enemas and other palliative measures.

The enterostomy for postoperative ileus described in Case 3 brings up the problem of the minimum length of the oral loop consistent with life in selecting a distended loop for enterostomy:

CASE 3.—S. M., a man, aged 19, Russian, was operated on for acute intestinal obstruction produced by evagination of the terminal ileum through a perforated ulcer of the urinary bladder. The stomach and small intestine were markedly dilated down to the terminal 12 inches of the ileum. The technic consisted in freeing the bowel and repairing the vesical ulcer. From the third to the eighteenth day, enemas were ineffectual, and the patient vomited in the absence of mouth feeding. Pituitary extract brought on a copious bowel evacuation with the expulsion of considerable gas on the fourteenth day, but all other attempts at catharsis resulted in failure. The patient's malnutrition increased, although he was not acutely toxic.

Ileostomy on the eighteenth day revealed: (1) distended stomach and dilated three fourths of the small intestine; (2) collapse of the remaining intestine; (3) mesenteric contraction of the collapsed intestine, and (4) adhesions. After ileostomy, the patient's appetite improved, his nausea and vomiting disappeared, and drainage continued profusely. The site of the stoma was apparently somewhere within the middle third of the small intestine. He declared that he could feel his food rushed out of his stomach and intestine into his dressings. The material recovered from the ileostomy was incompletely digested food. Inanition progressed until his death on the thirtieth day after admission.

ORAD LIMIT OF ENTEROSTOMY

Schilling²⁰ asks, "How long a segment of small intestine can we resect?" and his study of the literature fails to set any limit. Each case has to be decided by the individual condition. One might similarly ask, "How far orad may one safely make an enterostomy?" In the foregoing instance, the lower limit of the dilated

20. Schilling: Arch. f. Verdauungskr., December, 1921.

intestine was opened, a point probably within 8 feet of the ileocecal valve, but this site did not allow this patient sufficient working intestine to survive with in his wasted condition.

616 Madison Avenue.

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EXPERIMENTAL INTESTINAL OBSTRUCTION*

A STUDY IN SEVERED GUT OBSTRUCTION AND SEGMENTAL OBSTRUCTION

By **HARRY BELLEVILLE EISBERG, M.D.**

OF NEW YORK, N. Y.

FROM THE DEPARTMENT OF SURGERY, NEW YORK UNIVERSITY AND BELLEVUE HOSPITAL
MEDICAL COLLEGE

WHEN a number of investigators working at the same problem arrive at different conclusions, the confusion is at times ascribable to the fact that each one has worked out but a part of it. Moreover, the various findings may not have been properly interpreted and correlated, which of course often results in the presentation of divergent theories. As this would seem to be the case in connection with the experimental study of intestinal obstruction, the writer has attempted to approach the problem from this standpoint and correlate some of the widely contradictory views.

In the report here submitted, the writer has duplicated in part the work of others and also carried out a series of original experiments. Morphine-ether anæsthesia was employed in all of the operations.

In presenting the experimental data, it would seem expedient to arrange the subject matter into three groups, as follows:

Group I.—*Severed Gut Obstruction*: Observation made to show the existence of a distinct duodenal obstruction entity in which the pancreas plays the dominant rôle (Draper,^{1, 12} Sweet, *et al.*²).

Group II.—*Segmental Obstruction*: Observations made to show the existence of a distinct intoxication resulting from intestinal segments or loops (Roger,³ Whipple, *et al.*,⁴ Murphy and Brooks,⁵ Dragstedt, *et al.*⁶).

Group III.—An attempt to clear up certain points of discord between the various observers.

GROUP I.—*Severed Gut Obstruction*: The first group of investigators produced an obstruction in the duodenum by simple severance and closure of the oral and aboral ends. Following this operation the animal has a few hours of normal existence and then rather suddenly develops a group of characteristic symptoms, namely, rapid pulse, vomiting, tremors, spasticity of the hind legs, and finally prostration and death occurs within a few days. This symptom-complex is, in the main, afebrile. Autopsy reveals (outside of the experimental obstruction) congestion of the viscera (liver, spleen and kidneys) with marked congestion of the mucosa of the terminal colon and to a less degree congestion of the gastric and duodenal mucosa.

Simple severance of the gut (Fig. 1) and invagination of both ends,

EXPERIMENTAL INTESTINAL OBSTRUCTION

if placed just aboral to the bile and pancreatic ducts,⁷ is followed by death in from thirty-six to ninety-six hours. When the obstruction is placed orally or aborally to this point (Figs. 2, 3 and 4) the length of life

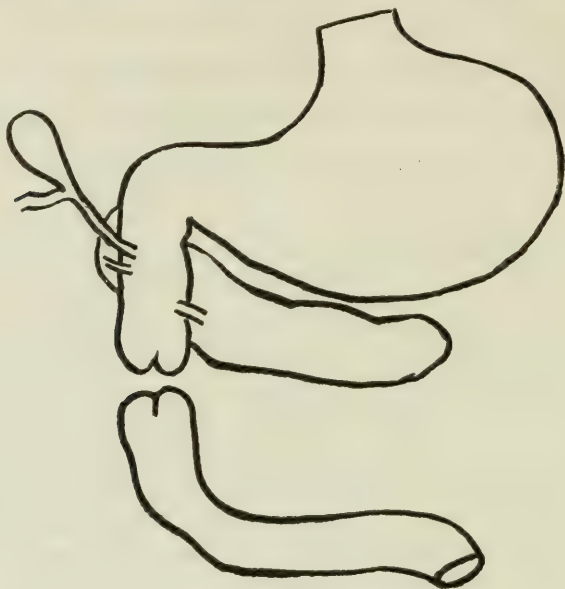


FIG. 1.



FIG. 2.



FIG. 3.

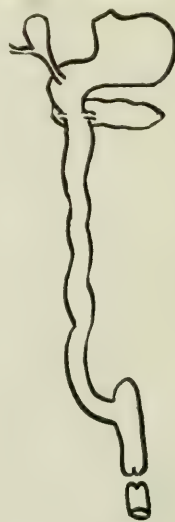


FIG. 4.

is increased and the attendant symptom-complex is changed.⁸ The small amount of necrotic tissue coincident with invagination of the gut cannot be held responsible for the death of the animal, on the ground that this factor remains the same irrespective of the location of the obstruction.

These experiments show that there is a point in the duodenum at which obstruction is more lethal than at any other point in the entire bowel.

In a previous communication the writer and Doctor Draper⁸ reported the result of implanting the aboral end of a duodenal transplant with its outbuds, 15 cm. in length (the oral end of which was occluded), into the ileum. At the same time the continuity of the canal was reestablished by a gastrojejunostomy (Fig. 5). Subsequently a severed gut obstruction was made 35 cm. from the gastrojejunostomy opening, *i.e.*, oral to the site of the transplant (Fig. 6). In control animals a similar obstruction, also 35 cm. from the pylorus, was fashioned without transplantation of the duodenum and its outbuds (Fig. 7). The transplant animals lived seventeen days; the control animals lived six days. This

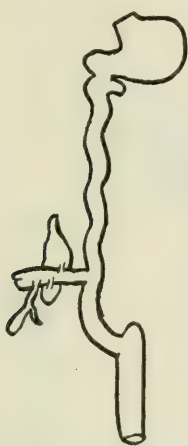


FIG. 5.



FIG. 6.

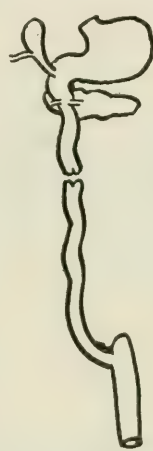


FIG. 7.

seventeen-day period of life is three days longer than that of an obstruction at the ileocecal sphincter (fourteen days) with the duodenum and its ducts left in their normal position. All fulminating toxic symptoms were absent in the transplant animals.

In the following experiments a 15 cm. duodenal transplant with its oral and aboral ends occluded was employed. A gastrojejunostomy was performed to establish continuity of the gut (Fig. 8). These animals died within twenty-four hours, the result of a partially distended devitalized transplant (segment). Death occurred before all the characteristic symptoms of high obstruction developed. Furthermore, if the oral end of this transplant was drained externally (Fig. 9) the animal lived for several days without exhibiting any of the signs of obstruction.

In conjunction with these experiments it was demonstrated that animals in which the entire duodenal contents were drained externally lived as long as animals obstructed in the same portion of the gut; a similar condition of affairs obtained in connection with the jejunum. However,

EXPERIMENTAL INTESTINAL OBSTRUCTION

in both instances the attendant symptomatology was entirely different than occurred in the obstructed animals.

PROTOCOLS OF CASES (SERIES OF 1920). NUMBER OF DOGS, 9*

Dog 126.—Large male, brown and white. Operation (Fig. 8): Gastrojejunostomy. Pyloric section—inversion oral and aboral ends; duodenal section 4 cm. below bile and pancreatic ducts, inversion oral and aboral ends. Marked

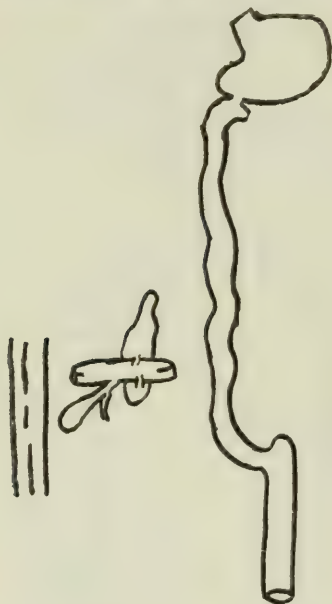


FIG. 8.

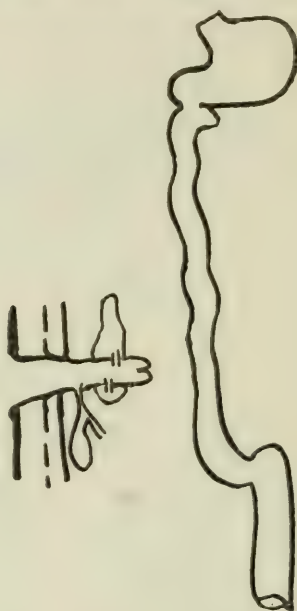


FIG. 9.

prostration followed by death within eighteen hours. Autopsy: Surgical pathology produced: partially devitalized segment, free sero-sanguinous fluid in abdomen, no peritonitis, intestinal mucosa congested throughout.

Dog 51.—Small, brown male. Operation (Fig. 9): Gastrojejunostomy. Pyloric section, inversion oral and aboral ends; duodenal section 4 cm. below pancreatic and bile ducts, oral end inverted, aboral end drawn through incision, sutured in place, left patent; animal died within seventy-eight hours. No fulminating symptoms. Post-mortem: Skin excoriation, gastrojejunostomy opening was patent, omentum wrapped around transplant, slight congestion of peritoneum at site of wound, no congestion of intestinal mucosa.

Dog 55.—Medium, black and white, hairy female. Operation: Duodenal drainage. Duodenum severed below bile and pancreatic ducts; oral end inverted, aboral end drawn through incision and sutured in place. Animal lived ninety-two hours. No fulminating symptoms; gradual increasing weakness and death. Post-mortem: Marked skin excoriation, no congestion of intestinal mucosa; stomach markedly contracted.

* The statement "number of dogs" placed after "Protocol of Cases" throughout this presentation, refers only to the number of dogs in which it was possible to record positive findings. In each series of experiments a much larger number of dogs was used; many of these died of accidental complications and are for this reason not included in the number stated.

Dog 109A.—Small, white terrier, female. Operation: Jejunal drainage. Jejunum severed 30 cm. from duodenojejunal ligament; oral end inverted, aboral end drawn through skin incision and sutured in place. Duration of life 186 hours. Gradual weakness and death without fulminating symptoms. Post-mortem: Skin excoriated; stomach markedly contracted; slight peritoneal congestion at wound margin. No congestion of intestinal mucosa.

These experiments would seem to bear out the supposition that the duodenum with its outbuds produces the lethal toxins of high intestinal obstruction; that the gastro-toxins isolated by Roger⁹ do not produce a true picture of duodenal obstruction, and that the intestinal canal does

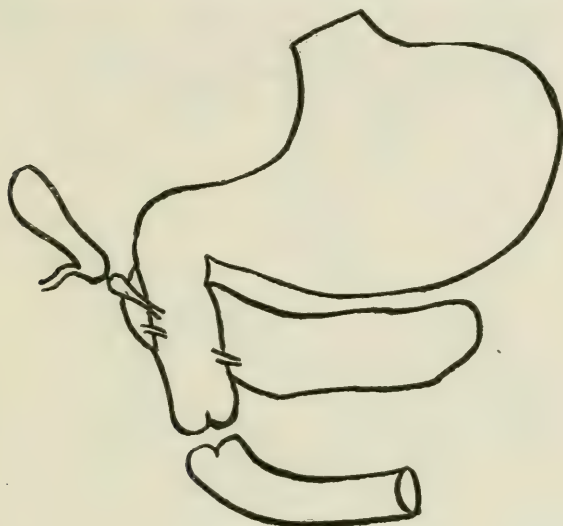


FIG. 10.

not produce a very marked toxæmia if the duodenum and its outbuds are transplanted into the gut below the obstruction.

With regard to the toxicity of the bile in connection with severed gut obstruction, it was found that when the common bile-duct was ligated, the dog lived for several weeks. However, if the gut was obstructed below the entrance of the pancreatic ducts, and the common bile-duct was ligated with or without drainage of the gall-bladder (Figs. 10 and 11), the animal died within thirty to ninety-six hours with the characteristic symptoms of high intestinal obstruction.

PROTOCOLS OF CASES (SERIES OF 1918). NUMBER OF DOGS, 6

Dog 201.—Small male, black and white. Operation: Common bile duct ligated. Duration of life sixteen days. Autopsy: Gall-bladder distended; common duct found severed and ligated.

Dog 214.—Male, brown. Operation (Fig. 10): Common bile duct ligated. Intestine obstructed below the pancreatic and bile ducts. Symptoms characteristic of high

EXPERIMENTAL INTESTINAL OBSTRUCTION

intestinal obstruction. Duration of life ninety-five hours. Autopsy: Gall-bladder distended; common duct ligated; liver congested (black); stomach somewhat dilated; congestion of gastric, duodenal and colon mucosa.

Dog 206.—Medium, female, brown and white. Operation (Fig. 11): Gall-

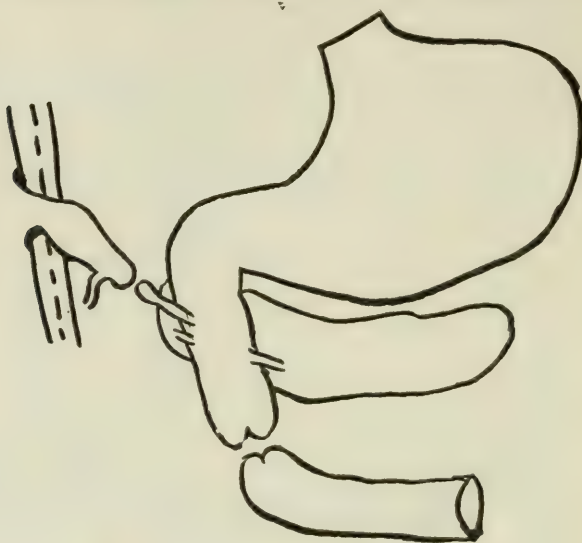


FIG. 11.

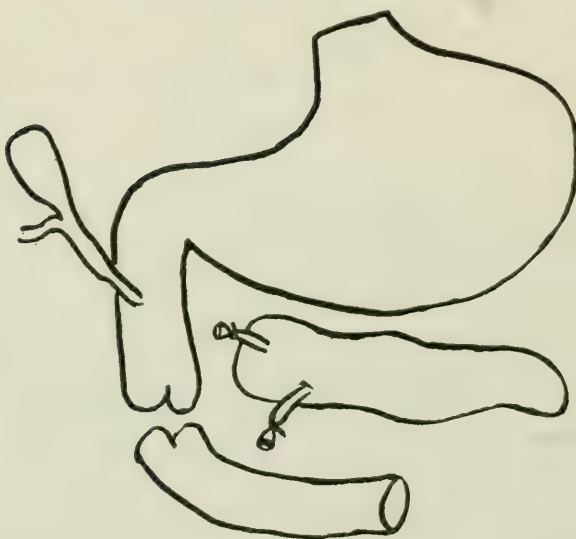


FIG. 12.

bladder drained externally; common duct ligated. Intestine obstructed below pancreatic and bile ducts. Duration of life sixty-five hours. Symptoms those of intestinal obstruction. Autopsy: Surgical pathology produced, plus that obtained in severed gut obstruction.

Meltzer and Salant¹⁰ have shown that the normal bile from many rabbits possesses an element which will produce chronic convulsions in frogs. Roger¹¹ has also shown the toxicity of bile. However, in these experiments this toxicity is a negative factor.

These observations agree with those of Draper¹² who stated: "It did not matter whether the bile emptied into the oral or aboral loop near the point of obstruction; whether the duct was simply ligated or cut or whether cholecystileostomy was done, the lethal outcome appeared rather conclusively still to be dependent entirely upon the position of the obstruction."

The influence of the pancreas in severed gut obstruction was studied by ligation of both pancreatic ducts with the duodenum (Fig. 12) obstructed. Some of these animals lived five to seven days. In similar

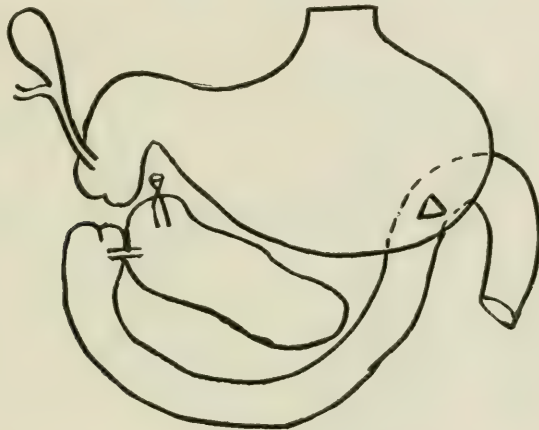


FIG. 13a.

experiments (Sweet, *et al.*²) the animals lived seven to eight days. None of these animals died with the symptoms of high intestinal obstruction.

Draper¹³ performed this experiment somewhat differently, ligating the lesser pancreatic duct. The gut was obstructed above the greater pancreatic duct in some cases, and in others below it. A gastroenterostomy stoma control was added (Fig. 13a and b). If the obstruction was placed oral to the duct the animals lived during the stoma control, which was seventy-two hours; if placed below, they died during stoma control.

PROTOCOLS OF CASES (SERIES OF 1920). NUMBER OF DOGS, 3

Dog 130.—Medium, male, brown and white. Operation (Fig. 12): Ducts ligated. Obstruction placed below pancreatic and bile ducts. Animal died 164 hours later without signs of high duodenal obstruction. Autopsy: Surgical pathology; very slight congestion of gastric and colon mucosa; omentum adherent to pancreas.

In another set of experiments Sweet, *et al.*,² isolated an ileal segment, restored the continuity of the gut, and, in some cases, filled the segment

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or loop with pancreatic juice, and in others with fresh dog's pancreas. A number of these animals died within the time limit of high intestinal obstruction with its characteristic symptoms. Roger and Garnier¹⁴ have demonstrated the toxicity of pancreatic juice, and also that this is increased when mixed with intestinal juice. Davis and Stone¹⁵ have shown that duodenal secretion from which the pancreatic juice is excluded is not toxic as long as it is kept from bacterial decomposition. Moorhead and Landes,¹⁶ Mann and Kawamura,¹⁷ as well as Dragstedt, *et al.*,¹⁸ have demonstrated that duodenectomy is compatible with life and perfect health for short periods of time at least.

Our experiments and the observations recorded above suggest that the pancreas plays an important rôle in high severed gut obstruction.

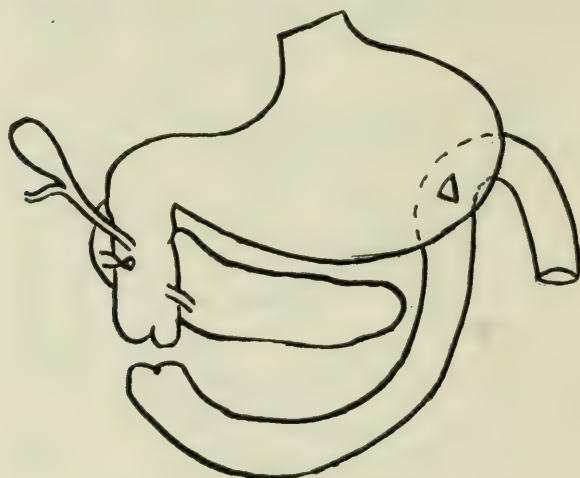


FIG. 13b.

This would also seem to show that the duodenal mucosa is not the determining toxic factor and that this membrane is not essential to life.

Sweet, *et al.*,² states: ". . . the explanation of the similarity between acute pancreatitis and acute high obstruction—they are alike because they are both essentially the same thing, an intoxication with the toxic products of protein cleavage, in pancreatitis certainly due to proteolytic ferments of the pancreas, in high obstruction not necessarily, perhaps, but in our opinion in all probability, the same toxin, produced by the same ferment. In pancreatitis the escape of the products of digestion of the pancreas into the tissues permits the intoxication; in obstruction, the conditions of obstruction permit the absorption of the toxic products, which under normal conditions would either not be formed, or if formed would be immediately broken down to non-toxic products."

GROUP II.—*Segmental Obstruction*: The second group of investigators produced a doubly occluded segment or loop, in some cases using a gas-

troenterostomy to drain the duodenum, in others reconstructing the gut; while in still others the continuity of the gut was interrupted, a tape being employed to isolate a segment or loop.

The life of the animal and the rapidity of the onset and the severity of the symptoms in this type of obstruction depend upon several factors: the size of the segment; the condition of its circulation, whether this is partly or completely occluded; the location of the segment and the consequent variations in the digestive activity of the mucosal cells; and the bacterial content of the segment. Death results within from three hours to three days. The fatal outcome is preceded by listlessness, "grogginess," rapid pulse, vomiting and rise of temperature; the last may become subnormal. In the very toxic cases the animal at once becomes markedly prostrated and soon dies.

Necropsy shows the experimental lesion consisting of a segment of

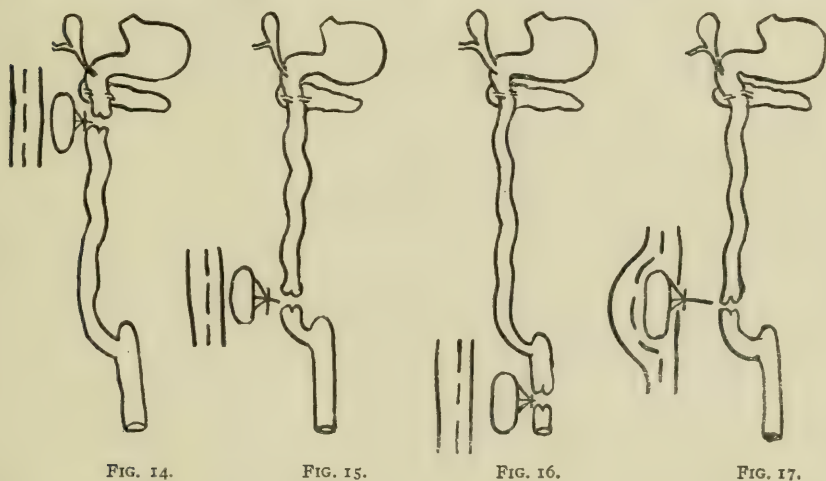


FIG. 14.

FIG. 15.

FIG. 16.

FIG. 17.

gut in different degrees of devitalization; free sero-sanguinous fluid in the peritoneal cavity; the engorgement of the liver, spleen and kidneys; congestion of the mucosa of the stomach, of the small intestine and, to a lesser degree, of the large intestine.

In the following series of experiments an excluded, bilaterally occluded segment about 20 cm. in length was used, the oral and aboral ends of the gut contiguous to the segment were inverted and closed. The circulation both to and from the segment was deligated, thus immediately devitalizing it. In each instance it was demonstrated that the experimental segment contained a colon-like bacillus. This exact procedure was carried out in the duodenojejunum (Fig. 14); in the ileum, 8 cm. oral to the ileocecal sphincter (Fig. 15), and in the colon region about 8 cm. oral to the anus (Fig. 16). All these segments were left within the peritoneal cavity.

In other animals ileal segments were placed between the fascial planes

EXPERIMENTAL INTESTINAL OBSTRUCTION

of the abdominal wall (Fig. 17), and in still others the segment was placed exterior to the skin (Fig. 18).

All the animals died within seventy-two hours except those in which the segment was placed externally to the skin, in the latter event the segment had no effect on the health of the animal. Of the intraperitoneal segments, those fashioned from the duodenum were the most toxic, death occurring within twenty and one-half hours; those derived from the ileum were fatal in twenty-three to twenty-four hours, and those from the colon died in thirty-five to seventy-two hours. In the fascial segments located between the planes death occurred within twenty-six hours.

Since the dogs in Group II, just described, also had an associated severed gut obstruction (refer to Figs. 14, 15, 16, 17 and 18) oral to the

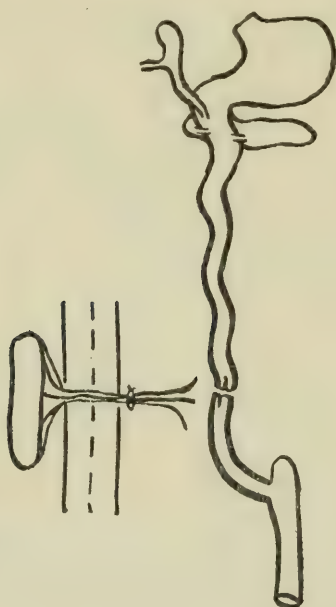


FIG. 18.



FIG. 19.

excluded segment, it is important to consider the significance of this in relation to the segmental type of obstruction.

None of these animals presented a typical picture of high severed gut obstruction, although the actual mechanical obstruction existed. The exception to this was noted when the obstruction existed in the duodenum (where the severed gut obstruction is most toxic), in which event some of the animals exhibited slight spasticity of the hind legs. It has been shown that in high severed gut obstruction most of the animals have a symptomless period of from eighteen to twenty-four hours in which they appear normal; while those animals with a devitalized segment become toxic and prostrated within this period and die within twenty-six hours, excepting when the segment is derived from the colon.

Excluding the confusing elements which arise in connection with a segmental obstruction in the duodenum where the two types are more or less associated, let us compare the length of life and symptoms of a simple severed obstruction in the ileum with those in connection with the isolation of an ileal segment. In the former instance the animal lives about fourteen days with signs of emaciation and gradual weakness until death intervenes and no fulminating symptoms develop, while in the latter instance (segmental obstruction) the animal dies within twenty-four hours with only a few hours of freedom from symptoms; this period is promptly followed by listlessness, unsteady gait (not spastic), marked weakness, and finally prostration and death.

When a severed gut obstruction is produced at the rectum the same picture develops as in the ileum, except that the animal lives twenty-eight days, while a segmental type of obstruction in this location is followed by death in from thirty-five to seventy-two hours. Hence, the ileal and rectal segments represent almost a pure type of segmental obstruction and present the same picture as though the continuity of the bowel were restored. Surely this would seem to show that the two types of obstruction are of a different nature.

In another series of animals segments 30 cm. to almost the whole length of the small intestine from the duodenojejunal ligament to the ileocecal sphincter were employed. These loops* were produced by knotting the gut itself (Fig. 19); by simple twist of the gut (Fig. 20); and by pulling a loop of gut through a rent in the mesocolon (Fig. 21). In some of these cases the circulation was immediately occluded (knotting) and in others the circulatory nutrition was gradually interfered with by peristalsis and filling of the loop with its own secretion and transudate, and consequent distention.

In this series of observations the animals died within three to forty-two hours, with symptoms varying from marked prostration, from which the animal never recovered, to those observed in the segmental experiments just described. The length of life and severity of the symptoms in these loop cases apparently did not depend so much upon the size of the loop as upon interference with the blood supply to the loop and its location. In the large loops where the circulation was immediately cut off death occurred within from three to seven hours. In the instance in which the gut was drawn through the rent in the mesocolon with the gradual occlusion of the circulation, the animal lived forty-two hours despite the fact that the loop was 80 cm. in length.

In the following experiments a segment of gut in the duodenojejunum was isolated without deliberate interference with its circulation. In

* The term "segment" is used to denote an arrangement of gut as shown in Fig. 15; the term "loop" is used to designate the condition of affairs shown in Fig. 21.

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some cases the continuity of the gut was restored (Fig. 24, a and b). In other cases the ends were inverted or a segment isolated with tape (Figs. 22, a and b; 23, a and b), whereupon a functional or severed gut obstruction was established above the point of isolation of the segment. In the dogs in which the continuity of the gut was not reestablished and no

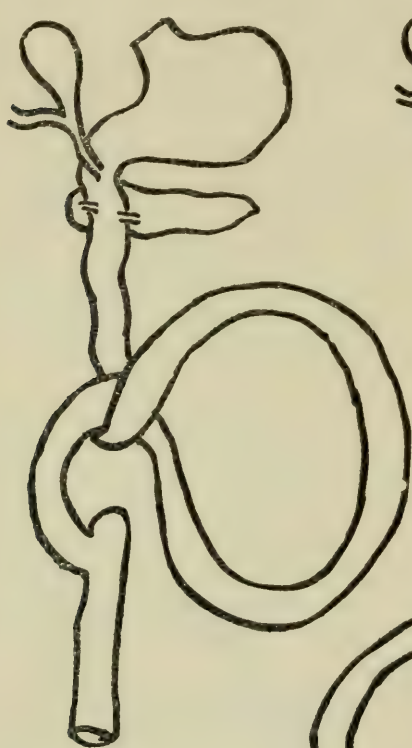


FIG. 20.

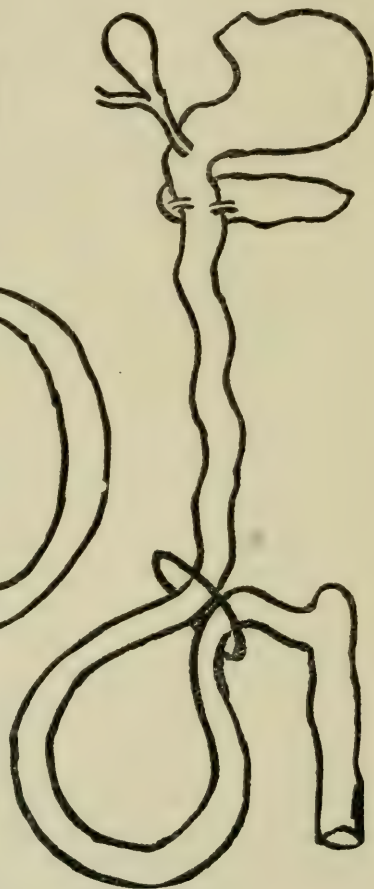


FIG. 21.

spontaneous distention of the segment occurred (Figs. 22, a, and 23, a) death followed within sixty hours. In those cases the segment appeared perfectly normal, showing no evidence of devitalization: that is to say, the death of the animal was the outcome of the existing severed gut obstruction. On the other hand, if under the same conditions the segment became spontaneously distended and later hemorrhagic in color, and finally devitalized (Figs. 22b and 23b), death occurred within from twenty-four to thirty-six hours. Here a combination of the severed

gut obstruction and segmental obstruction was responsible for the death of the animal, the latter (segmental obstruction) being the dominant one.

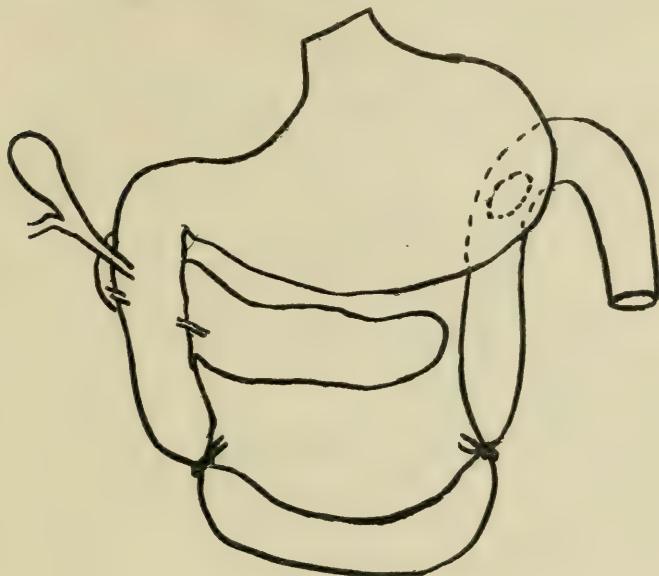


FIG. 22a.

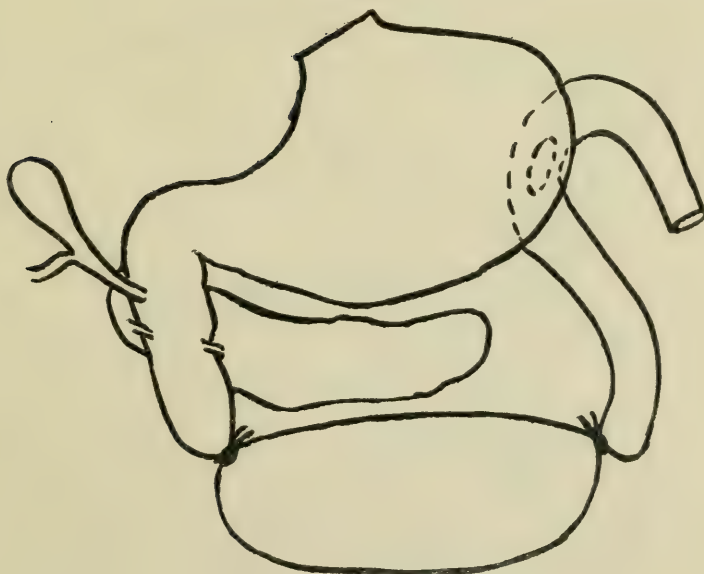


FIG. 22b.

In those cases in which reconstruction of the bowel was practiced (Fig. 24, a) and no devitalization of the loop occurred, the animals lived several weeks. However, if the segment (Fig. 24, b) became devital-

EXPERIMENTAL INTESTINAL OBSTRUCTION

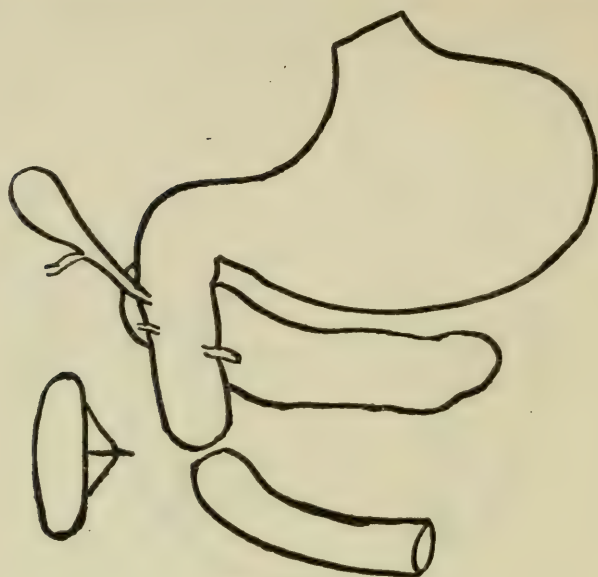


FIG. 23a.

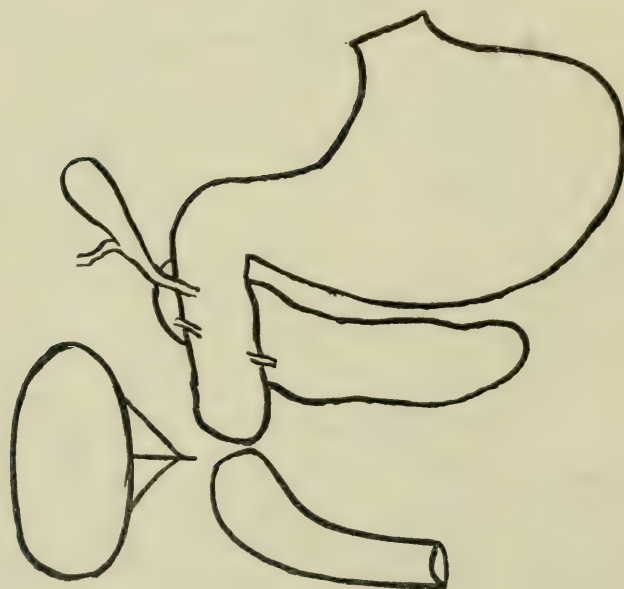


FIG. 23b.

ized and was not removed the animal died within forty-eight hours; the death in this case being due to causes arising in connection with the segment itself, as no severed gut obstruction existed above.

HARRY BELLEVILLE EISBERG

PROTOCOLS OF CASES (SERIES OF 1916, 1917, 1919, 1920). NUMBER OF DOGS, 35

Dog 108.—Female, small, white terrier. Operation (Fig. 14): Duodenal devitalized segment. Duration of life was twenty and one-half hours. Autopsy:

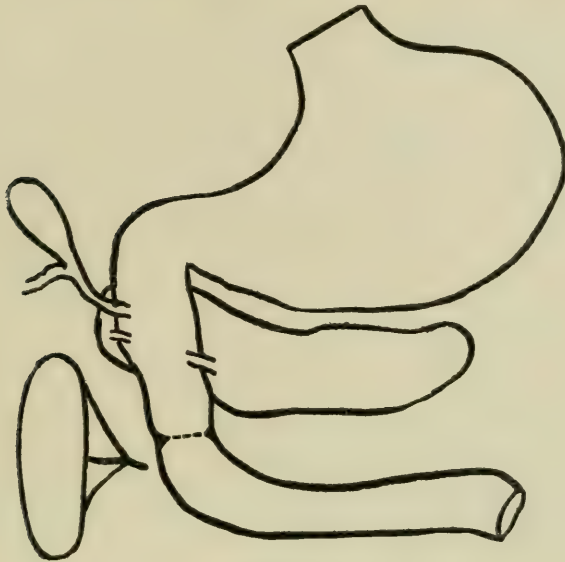


FIG. 24a.

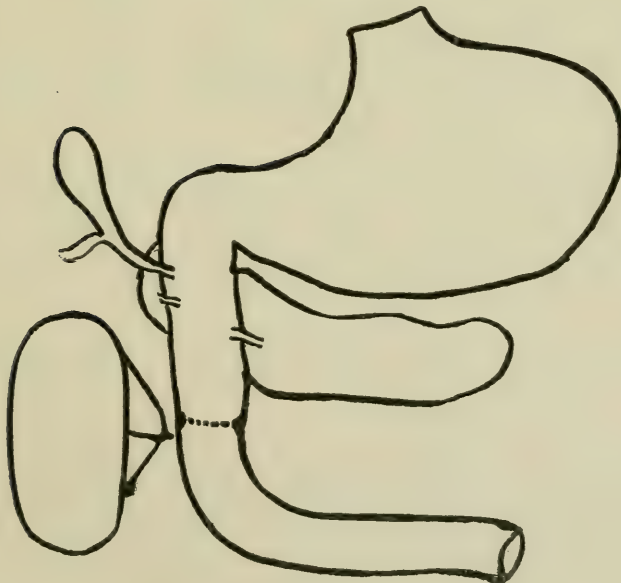


FIG. 24b.

Free sero-sanguinous in peritoneal cavity; 20 cm. of devitalized partially distended segment; no reconstruction. Congestion of intestinal mucosa small gut; slight congestion of colon; engorgement of liver and spleen.

EXPERIMENTAL INTESTINAL OBSTRUCTION

Dog 106A.—Male, small brown, short-haired. Operation (Fig. 15): Ileal devitalized segment. Duration of life was twenty-three hours. Autopsy: As in dog 108, with the following exceptions; Ileal segment employed instead of a duodenal segment, and that the intestinal congestion was not so marked.

Dog 133.—Female, medium, brown and white. Operation (Fig. 16): Colon devitalized segment. Duration of life was seventy hours. Autopsy: Colon devitalized segment; some free fluid in peritoneal cavity, less than in other segments; congestion of intestinal canal was less than in small intestinal segments.

Dog 87.—Male, small, black and brown, short-haired. Operation (Fig. 17): Ileal devitalized segment placed under the skin between superficial and deep fascia. Duration of life, twenty-six hours. Autopsy: No free fluid in abdominal cavity; slight congestion in parts of small intestines, none of duodenum or colon; abdominal parietes infiltrated with a sero-sanguinous fluid as occurs in the peritoneal cavity containing a devitalized segment; a segment was found in the fascial planes, from which a colon-like bacillus and a staphylococcus were isolated. The latter was probably a contamination.

Dog 109A.—Female, small white terrier. Operation (Fig. 18): Ileal segment exterior to skin; segment removed twenty-four hours later, gut reconstructed; no toxic symptoms developed. Animal made an uneventful recovery.

Dog 86.—Male, small, brown, short-haired. Operation (Fig. 19): Ileal loop 50 cm. in length knotted. Duration of life, ten to twelve hours. Autopsy: Surgical pathology produced (50 cm. devitalized loop); free sero-sanguinous fluid in peritoneal cavity. Marked congestion of stomach, duodenum, small intestine and colon.

Dog 101.—Male, medium, brindle mongrel. Operation (Fig. 20): Entire small gut accidentally twisted while forming an ileal segment. Duration of life three hours and three minutes. Autopsy: Gut twisted from duodenojejunal ligament to terminal ileum, marked dilatation and congestion; ileal segment devitalized; colon showed a slight congestion; free sero-sanguinous fluid in peritoneal cavity.

Dog 88.—Male, large, short-haired bull terrier. Operation (Fig. 21): Ileal segment removed (previous operation) and a rent in mesentery produced through which 80 cm. of small gut slid. Duration of life, forty-two hours. Autopsy: 80 cm. strangulated small intestine; gradual devitalization which accounts for the longer duration of life; free fluid in peritoneal cavity; slight congestion of the rest of the small intestine and slight congestion of colon.

Dog 53.—Male, small, brown and white terrier. Operation: Jejunal ileal segment 96 cm. in length; circulation ligated. Duration of life, six hours. Autopsy: 96 cm. partially distended, devitalized segment; free fluid in peritoneal cavity; congestion of small gut and colon.

Dog 256.—Female, medium, brown and white. Operation (Fig. 22, a): Duodenojejunal segment 40 cm. in length; tape used to isolate segment; no interference to the circulation; posterior gastrojejunostomy. Duration of life, ninety hours. Symptoms of severed gut obstruction. Autopsy: No free fluid in peritoneal cavity; surgical pathology produced; segment not distended nor discolored, contained small amount of whitish pasty substance. Gastric, duodenal and terminal colon mucosa congested.

Dog 240.—Male, small, brown. Operation (Fig. 22, b): Segment 40 cm. in length; tape used to isolate segment; no interference to the circulation; posterior gastrojejunostomy. Duration of life, seventy-four hours. Symptoms of severed

gut and segmental obstruction. Autopsy: Surgical pathology produced, segment black in color, markedly distended; congestion of gastric mucosa, small and large intestinal mucosa; free fluid in peritoneal cavity.

Dog 303.—Male, large, white. Operation (Fig. 23, a): Segment 40 cm. in length; no interference to the circulation; no reconstruction of the gut. Symptoms of severed gut obstruction. Duration of life, forty-eight hours. Autopsy: Surgical pathology produced; no distention of segment; no free fluid in peritoneal cavity; congestion of duodenal, gastric and colon mucosa.

Dog 309.—Male, large, black. Operation (Fig. 23, b): Segment 30 cm. in length; no interference to the circulation; no reconstruction of the gut. Duration of life, thirty-six hours. Symptoms of severed gut and segmental obstruction. Autopsy: Surgical pathology produced; segment distended, dark hemorrhagic in color; free fluid in peritoneal cavity; no observation on congestion of intestinal mucosa made.

Dog 291.—Female, medium, black and white. Operation (Fig. 24, a): Jejunal segment 40 cm. in length; no interference to the circulation; reconstruction of bowel; end-to-end anastomosis. Dog made an uneventful recovery. Two weeks later, dog sacrificed, chloroform anesthesia; blood removed for chemical study. Autopsy: Segments normal in appearance, not distended; omentum wrapped around segments; anastomosis in good condition; no intestinal congestion.

Dog 278.—Female, large, black and white. Operation (Fig. 24, b): Duodenojejunal segment 50 cm. in length; no interference to circulation; reconstruction of bowel; lateral anastomosis. Symptoms of segmental obstruction. Duration of life, fifty-six hours. Autopsy: Surgical pathology produced; segment distended; free fluid in peritoneal cavity; slight congestion gastric, small and large intestine mucosa.

These experiments definitely show that the changes in isolated devitalized segments are responsible for the lethal outcome.

In some instances when duodenojejunal segments were isolated and the circulation was not interfered with and the continuity of the gut restored, the segments did not distend nor become devitalized and the animals did not develop untoward symptoms, while, on the other hand, in a certain number of animals in which the conditions were in every regard similar to those just stated, the segment did become distended and devitalized and the animals presented the picture of segmental obstruction and soon died. When the same conditions were produced in the ileum and colon, the result in by far the greater number of cases was similar to what occurred in the duodenojejunum when no devitalization was present.

The reason why isolated segments (continuity of the gut restored) of the small intestine, especially those located in the duodenojejunum, frequently distend and become devitalized even though the circulation is not deliberately interfered with, whereas those in the colon become distended but not devitalized, is because of the preponderance of the secretory over the absorption phase in the small intestine, while the reverse obtains in the colon. Attention was called to this fact by Obalinski.¹⁹ Although the colon segments were practically empty at the

time of their isolation, they later became filled with material, much distended and the intestinal wall hypertrophied. This was observed by Blake and Brown.²⁰ However, in the small intestinal segments the secretion appeared more rapidly and the distention interfered with the circulation before a compensatory state had time to develop.

This explanation cannot be applied to those instances in which the isolated duodenojejunal segment does not become devitalized, for the reason that were interference with the circulation necessarily the outcome of the domination of the secretory phase and consequent distention and devitalization, this would occur in every instance, while such is not the case. Therefore, it is necessary to search for another factor as causative in this connection.

It is suggested that the greater motility of an isolated segment of small intestine renders it more responsive to peristalsis, and thus a comparatively slight torsion of its mesenteric attachment may partially interfere with the circulation (circulatory stasis), and this in turn becomes responsible for a rapid filling of the segment with a bloody transudate and intestinal secretion. If this be true, the conditions may be regarded as important factors in the devitalization of isolated segment in which there has not been a deliberate interference with the circulation.

This conception (based on the observation in Groups I and II) argues that bacteria are not the all-important factor in the cause of death in experimental obstruction. Certainly in the severed gut type they appear to play no part; the only pabulum is the devitalized tissue at the site of inversion, and if this small amount of necrotic tissue were sufficient to cause death the symptom-complex of obstruction in the duodenum and colon regions would be the same. Instead of this, there is a difference of about twenty days between colon and duodenum (severed gut obstruction) in duration of life.

In the second group of observations, the segmental obstruction is compatible with life if the continuity of the gut be restored and if there is no devitalization of tissue, although bacteria are present in the segment.

However, when devitalization of tissue occurs there is a pabulum for bacteria and the production of toxic substances must follow.

When death occurs early (three to seven hours) after a large loop or segment has been isolated and its circulation abolished, one must search for some other cause for death than the action of bacteria upon devitalized tissue. It is, therefore, submitted that the specialization of the digestive cell, which is greatest in the duodenojejunum, is the foremost lethal factor, while the action of bacteria is a secondary one in segments devitalized by immediate interference with the circulation. However, it is not improbable that in gradually devitalized segments (the outcome of distention and circulatory stasis) bacterial action is the important pernicious factor because of the period of incubation thus presented.

From an experimental standpoint, putrefaction, the outcome of bac-

terial action upon nitrogenous foodstuffs, may be disregarded on the ground that the entire complex stated above may obtain in fasting animals. The toxicity of segmental obstruction may be increased if food is present in the segment, but this may be regarded as a minor factor. This view is supported by the fact that a simple severed gut obstruction at the rectum permits the animal weeks of life without the appearance of fulminating symptoms, and surely putrefaction must be very active under these conditions.

To summarize with regard to Group II (segmental obstruction): The evidence at hand suggests that the toxic products of protein cleavage may be a primary cause of death and that these cleavage products are the result of proteolytic action on somatic cells the death of which is the outcome of interference with their blood supply. The action of bacteria on devitalized tissue is no doubt of secondary importance. However, they must become a prominent factor when the circulation is gradually occluded. As the investigation of the activities of intestinal anaërobic bacteria is still without definite result, the future may show that bacteria are more of a factor in segmental obstruction than now seems to be the case.

GROUP III.—An attempt to clear up certain points of discord between the various observers.

Of the many observers working with intestinal segments or loops almost all, except Draper⁸ and Sweet² and his co-workers, have disregarded the importance of the simultaneous presence of the severed gut obstruction (functional obstruction) oral to the isolated segment. To Sweet² belongs the credit of demonstrating the importance of the pancreas in simple severed gut obstruction.

Roger²¹ was one of the early observers to study this intricate problem of intestinal obstruction from a chemical and toxicological standpoint. He and his associates, notably Garnier, isolated the toxins (including toxic proteoses) from the different portions of the intestinal canal. They studied the toxicity of the stomach contents, of the bile, and of the pancreatic juice. They demonstrated that the toxins derived from the intestinal mucosa are more toxic than those extracted from the contents of the gut, and that the duodenal mucosa possesses a greater toxicity than that of the ileum. Their bacteriological studies encompassed the aërobic and the anaërobic groups.

Viewing the experimental work just mentioned as a whole, one gets the impression that the isolation of a single lethal, toxic agent in both the types of obstruction under consideration is impossible, and that a number of substances must be taken into account in animals whose condition is normal except for the experimental obstruction. While this may be true, our experimental work seems to establish a relative lethal importance as far as these various factors are concerned.

Whipple⁴ and his co-workers studied the loop or segmental type of

obstruction, and their isolation of a toxic protease was considered the lethal agent. That this protease is composed of one or more primary proteases and perhaps some B-nucleoprotein and nucleohiston is a later view toward which Whipple²² seems to lean.

However, Whipple's contention that the toxæmia is the outcome of a perversion of secretion or of a pernicious activity of the mucosa is difficult to understand, unless one assumes that the perversion of secretion may be the result of circulatory disturbances despite the fact that the blood supply of the segment is not deliberately interfered with. This

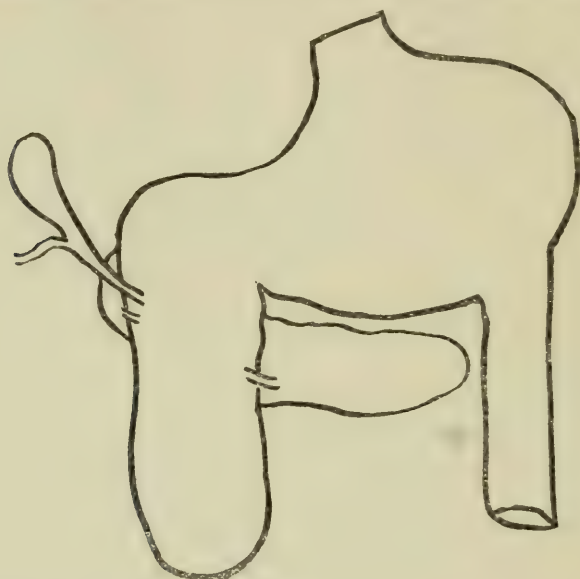


FIG. 25.

is borne out by the observation that the presence of segments in which no circulatory changes have occurred is compatible with life provided the continuity of the gut is restored.

With regard to the experiments of Whipple, *et al.*,⁴ in which the animals died, and autopsy showed only the loop of intestine which contained a certain amount of pasty material and no histological evidence of injury to the mucosa; Sweet, *et al.*,² called attention to the fact that in these animals a functional obstruction (severed gut type) existed oral to the segment (Fig. 22, a) and that the simultaneous presence of a gastroenterostomy did not necessarily drain the duodenum above the obstruction. Sweet and his co-workers proved this experimentally. That is, they showed that the duodenum was drained by a gastroenterostomy only when the duodenum dilated and became hypertrophied (Fig. 25); under these conditions the animal survived. On the other hand, if the duodenum did not undergo the changes stated above, the gastroenterostomy was not effective as an oral drain (Fig. 26) and the animal died.

A similar explanation of the fatal outcome is applicable to the experiments (Fig. 27) of Whipple, *et al.*, in which, although the segment was drained externally and even freely washed out, the animals died because the oral gut was not drained by the gastroenterostomy. In addition to this, Sweet and his coworkers further proved the rationale of their contention when they isolated a segment of the duodenum (similar to that of Whipple, *et al.*) but restored the continuity of the gut and at the same

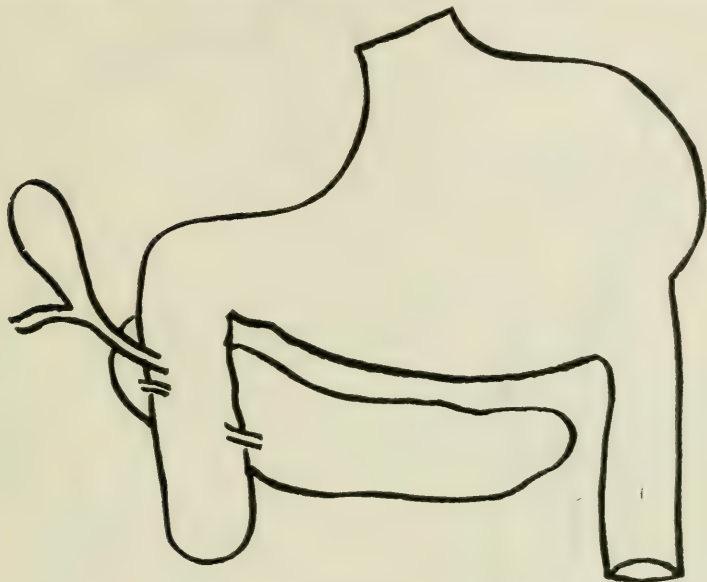


FIG. 26.

time demonstrated that when either end of the isolated segment was drained the animal remained normal. This operation really consists in establishing a Thiry-Vella fistula (unilateral occluded segment).

Draper,⁷ after experimenting with Thiry-Vella fistulae, observed that at the end of four or five days the animals showed marked evidence of toxæmia, rapidly lost weight and died within a short period of time. However, when the mucosa was removed from the isolated segment none of the symptoms stated developed. These findings would seem to accord with those of Whipple, *et al.*

The observations of the writer in connection with Thiry-Vella fistula would seem to justify acceptance of the views of Sweet.

PROTOCOLS OF EXPERIMENTS (SERIES OF 1916-1917). NUMBER OF DOGS, 3

Dog 167.—Female, small fox terrier. Operation March 12, 1917; Thiry-Vella fistula. Animal died June 17, 1917. Duration of life, ninety-seven days. No fulminating toxic symptoms developed. Animal became gradually emaciated. Autopsy: Negative as to actual cause of death.

In this series of experiments death occurred rapidly in three instances; the fatal outcome, however, was due to the presence of a de-

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vitalized segment (unilateral occlusion), to peritonitis and to a pancreatic abscess and was not the result of a toxæmia sequential to the absorption from the duodenal segment (unilateral occlusion).

Certainly if a toxæmia is produced it is not a pernicious factor as compared to the effects of either of the obstructions under consideration. The rapid death in Whipple's experiment (Fig. 27) must be

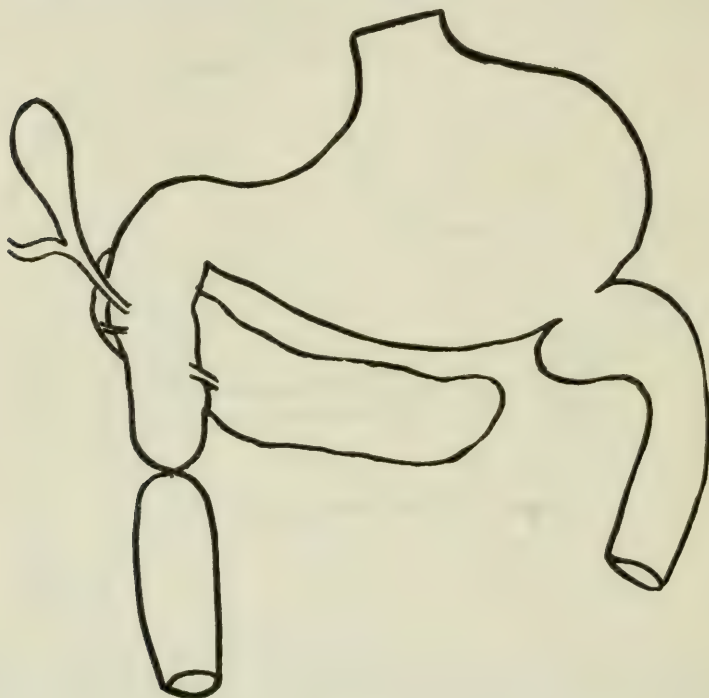


FIG. 27.

attributed, as Sweet suggested, to the oral functional obstruction (severed gut obstruction).

The view advanced by Sweet, *et al.*,² which Draper⁸ and his associates at one time were inclined to accept, that when a segmental obstruction was fashioned, the proteose of Whipple was formed in the gut above (Figs. 22, b; 23, b) the point of obstruction and excreted into this segment, cannot be reconciled to the fact that in the presence of a segmental obstruction in which the continuity of the gut was restored (Fig. 24, b) and the animal died. However, if the isolated segment was not devitalized (Fig. 24, a) the animal lived. This argues that the lethal toxin is formed in the segment and is not the result of the oral obstruction, for the reason that the obstruction element is removed from the problem by restoration of the continuity of the gut. This is one of the determining considerations in support of the belief that Whipple's entity is not the outcome of an oral functional obstruction.

The fact previously reported,⁸ into which the contents of isolated segments (with reconstruction of the continuity of the gut) was injected showed only slight or no evidence of intoxication, can only be explained on the ground that we committed a technical error in the isolation of the poison. Our conception at that time was that since no functional obstruction existed above the segment, no poison was formed. However, since this time we have on frequent occasions isolated a proteose under the very conditions under which we previously failed.

As to the character of the proteose from a chemical standpoint, it would seem that the poison consists of several further split products. This is supported by the fact that in chemistry a proteose is not regarded as toxic. This does not, however, exclude the conception that the intoxication may be dependent upon the product of further cleavage of the protein molecule. In any event, one must bear in mind that the intravenous injection of the poison or poisons is followed not by the signs of high severed gut, but of segmental gut obstruction.

PROTOCOLS OF CASES (SERIES OF 1916-1917). NUMBER OF DOGS, 10

Dog 221.—Female brindle, 6 kilos. 6/8/17—Ether anæsthesia 8.40 P.M. Kymograph observation throughout experiment. 8.45 P.M.—Blood pressure normal. Injection of 35 c.c. purified loop fluid (lethal dose). Primary rise of blood pressure—duration ten minutes. 9.50 P.M.—Pulse, 120, slight fall in pressure. 9.58—Temperature, 100. 10.00—Pulse, 114, semi-solid stool. Pressure normal. 10.25—Semi-solid stool. 10.45—Pulse 126, irregular diarrhœa. Pressure normal. 10.50—Temperature, 98. 11.15—Small semi-solid stool. 11.30—Respiration, 14; temperature, 94; pulse, 104, irregular. 11.45—Small semi-solid stool. 12.15—Bloody stool. 1.00 A.M.—Bloody stool. Temperature, 96; respiration, 16; pulse, 62; slight fall in pressure. 1.45—Bloody stool. 2.40—Temperature, 96.5; respiration, 20; pulse, 100, irregular. Still farther fall in blood pressure. Bloody stool. 3.30—Pulse imperceptible; profound prostration. Marked fall in blood pressure. 5.10—Animal dead. 5.30—Autopsy: Slight congestion of liver, spleen, and more or less throughout the stomach and intestinal mucosa. Colon contents blood tinged.

Dog 222.—Male, black and white. 6 kilos. 6/8/17—Ether anæsthesia 9.30 P.M., pulse, 100. 9.35—Intravenous injection 130 c.c. purified loop fluid (lethal dose). Compare with dog 221. 9.40—Pulse, 36; respiration, 18. Dog still under influence of ether. 10.00—Dog responds to whistle and call, staggers around. 10.10—Pulse, 60. 10.30—Animal became prostrate. Pulse, 186; temperature, 98. 10.55—Liquid and semi-solid stools. Profound prostration. 11.05—Diarrhœa. Animal attempts to walk around; urinates. 11.15—Bloody stools (diarrhœa). Prostration less. 11.35—Pulse, 132; respiration, 18; temperature, 97. Small watery stool. 11.50—Dog very weak; falls to floor when placed on feet. Small bloody stool. 12.40—Watery stool. Marked prostration. 1.00 A.M.—Diarrhœa. Pulse, 160; respiration, 15. Marked prostration. 1.30—Dog cold. 2.00—Pulse, 120. 2.10—Pulse, 150. 2.15—Pulse, 220. 2.20—Animal dead. Duration of life four hours and fifty minutes. 3.00—Autopsy: Same as dog 221, except for marked engorgement of liver and spleen. The congestion of stomach and intestine was much greater. Dog did not vomit.

Dog 223.—Male, large, brown. 10.45 P.M.—Ether anæsthesia. Preoperative pulse, 72; respiration, 25; temperature, 101. 10.50—Injection 115 c.c. mucosa extract de albuminized. After anæsthesia slight diarrhœa. No prostration. Animal recovered at once from anæsthesia and ran around. 11.00—Pulse, 186. 11.15—

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Resting. 11.40—Pulse, 72; respiration, 44; temperature, 99. Animal showed slight weakness. 1.00 A.M.—Pulse, 60; respiration, 26; temperature, 100. Weakness of hind legs. 1.30—Watery stool; no blood. 2.05—Hind legs still weaker. 2.30—Hind legs much stronger. 3.00—Pulse, 60; respiration, 26; temperature, 100. Dog in good condition. 3.10—Dog in good condition.

Murphy and Brooks⁵ suggested that in intestinal obstruction the presence of necrosis of the gut, together with the action of bacteria, were the important causative factors in the toxæmia attendant upon this condition.

Dragstedt⁶ and his associates, working along similar lines, were inclined to regard bacterial action as the dominant factor in the production of the toxæmia. They claim that the presence of sterile devitalized loops is compatible with life.

The fact that the presence of sterile devitalized segments of gut is not followed by death, does not answer the contention on part of the writer that duodenal segments are more toxic than those fashioned in the colon, nor does it make less true the fact that the isolation of large devitalized segments is rapidly fatal. The writer feels that though an abacterial segment is isolated in the abdominal cavity of the experimental animal, it is still capable of causing death because of liberation of a toxin the result of the breaking down of the host protein. This would explain why a duodenal segment is more toxic than one of the colon, on the ground that the digestive specialization of the cells of the mucosa is greater in the duodenum than it is in the colon; it also explains the rapid death when large devitalized segments are obstructed, as this means destruction of a greater area of cells. One of the possible fallacies of the explanation just offered might be developed in connection with further investigation of the action of anaërobic bacteria and their symbiosis with the aërobes acting on devitalized tissue. In this event, however, one would have to assume a degree of virulence on part of this combination of bacterial life not as yet demonstrated.

Further support of the non-bacterial character of the intoxication in segmental obstruction is supplied by Cooke and Whipple,²³ who produced a sterile abscess by means of turpentine injections, and acute pancreatitis by the injection of sterile bile. The advent of these conditions was followed by an intoxication very similar to that following an injection of a toxic proteose.

In investigating along these lines, the writer scraped out the mucosa of an isolated duodenal segment, thoroughly washed it and introduced the washed scrapings into the peritoneal sac of a normal dog. Following this one of three things happened: No reaction occurred; peritonitis developed; or the animal exhibited tremor, bloody stools, vomiting and rise of temperature, *i.e.*, a non-lethal picture of a proteose intoxication, such as follows intravenous injection, was provoked. Hence, it would seem permissible to assume that we produced a condition of affairs which was in no sense ascribable to bacterial action.

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PROTOCOL OF CASES (SERIES OF 1916-1917). NUMBER OF DOGS, 6

Dog 163.—Male, medium, 30 cm. caudad duodenum resected; end-to-end anastomosis. Duodenal mucosa washed thoroughly; mucosa scraped and introduced into the peritoneal cavity (homologous cells). Within thirty-six hours the dog passed bloody stools; apparent tenesmus; vomited once. Temperature, 102; pulse, 156. Urinary output increased and dog very thirsty on the following day; blood and mucus passed. Temperature, 102; pulse, 114, irregular. Slight tremors; no vomiting. Twenty-four hours later the dog made an uneventful recovery. Two weeks later the washed cells from an obstructed dog were introduced into the peritoneal cavity (Dog No. 163). Dog made an uneventful recovery without signs of obstruction. One week later washed cells from another obstructed dog were introduced into the peritoneal cavity (Dog No. 163). The dog died twenty-four hours later. Autopsy revealed a frank peritonitis.

The theory of Draper,⁷ that in severed gut obstruction the administration of the scrapings of jejunal mucosa suspended in water detoxicated the poison originating in the duodenal mucosa, is now regarded as fallacious, and it would seem that the beneficial effects produced may be properly ascribed to the watery contents of the mixture employed and not to any specific effect on the part of the jejunal scrapings. Hartwell and Hoguet²⁴ increased the duration of life in their obstructed animals by the copious administration of water. Their point of view that dehydration of tissue is the important factor with a secondary intoxication the result of dehydration, as the cause of death in severed gut obstruction, does not appear to be in accord with present views.

COMMENT AND SUMMARY

In the types of experimental intestinal obstruction discussed above, the toxins seem to have a two-fold origin. In severed gut obstruction in the duodenal region the pancreas is probably the main source of the toxin. Bacteria are apparently not a determining factor in this type of obstruction.

In the pure segmental type of obstruction (*i.e.*, an isolated segment with the continuity of the gut restored) the damaged intestinal tissue is the deciding factor as regards lethal outcome; if no devitalized tissue is present death does not occur. In non-devitalized segments bacteria alone will not be responsible for a lethal outcome. Surely at times a devitalized segment appears to be responsible for a lethal outcome long before there has been time for bacterial action to play a part in the result. When a severed gut and segmental obstruction are present together and there is no damage to the intestinal mucosa in the segment, the lethal outcome is due to the oral severed gut obstruction and not to the undamaged segments.

In both types of obstruction the breaking down of the host protein molecule appears to be an important factor in the formation of toxic substances. Whether the actual end products in both instances are chemically allied or not has yet to be proven.

In the severed gut obstruction death appears to be essentially a

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physiological one. In the devitalized segmental type this is true in the main; the added element being the presence of bacteria.

For the present the character of the toxic product in the former can only be conjectured, while in the latter the not clearly defined proteose or its split products may be regarded as the lethal agent.

In conclusion the writer wishes to express his thanks to Prof. George D. Stewart for the courtesy of the research laboratory. For the constructive criticism of this paper, the generous help of Professor Haubold and Doctor Draper was obtained. Professor Gettler gave his valuable assistance in elucidation of the chemistry of the problem. To Doctors Barber, Vejvoda, Stark and Otto the writer is indebted for their able assistance in the surgical procedures carried out in these experiments.

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PURPURA WITH GASTROINTESTINAL SYMPTOMS.

By W. HOWARD BARBER, M.D.,

NEW YORK.

FROM THE DEPARTMENT OF SURGERY, UNIVERSITY AND
BELLEVUE HOSPITAL MEDICAL COLLEGE.

PURPURA is generally recognized as a circulatory manifestation of a severe toxemia. It is characterized by hemorrhages into the skin, mucous, or serous membranes.¹ The extent of the extravasations of blood is supposed to correspond with the intensity of the intoxication. The purpuras are unsatisfactorily classified as symptomatic and essential or arthritic. The symptomatic purpuras depend upon or are associated with some recognized acute or chronic infection or toxemia (the acute exanthemata, typhus, typhoid, tuberculosis, ptomaines, snake venom, and certain drugs), constitutional disease (cancer, Hodgkin's, Bright's, scurvy) nervous diseases (tabes, myelitis), or trauma (varices, fractures). The essential purpuras include those in which both the causative agent and the mode of entry remain unknown and for purposes of description are spoken of as (1) the simple, affecting the skin, (2) the rheumatic or Schoenlein's disease, involving the skin and

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joints, (3) Henoch's purpura, in which the skin, joints, and gastrointestinal mucosæ are involved, (4) the hemorrhagic purpura or morbus maculosis of Werlhof, which is characterized by hemorrhages from all of the mucous membranes,² and (5) the fulminating type described by Calmels³ as occurring in children of five years with fatal results after from ten hours to four days. Little is actually known of the pathology of this obscure condition although Fraser⁴ has described purpura, on the basis of microscopical study of the blood-vessels taken at autopsies, as an inflammatory disease of the bloodvessel walls in which the blood is allowed to pass through into the surrounding tissues. Mouson⁵ emphasizes the importance of the blood platelets as the cause of the large group of true hemorrhagic purpuras but holds there are as many varieties of these hemorrhagic syndromes as there are factors in the mechanism of hemorrhage. In one, the wall of the vessel is at fault, as in slow endocarditis; in another, the coagulating ferments are lacking, as in sporadic hemophilia; in others nothing can be found to explain the hemorrhagic tendency, as in scurvy.

Henoch⁶ published his first report in 1874. He presented four cases, two boys and two girls, ranging in age from 4 to 15 years, with skin hemorrhages about the joints and blood in the stools. In these cases the "spots" appeared first and in one dysentery together with "spots" on the elbows. All showed remissions of the disease extending over a period of four to seven weeks. In 1876, two additional cases were reported by him. Osler contributed several cases in three separate reports on the subject. (*American Journal of the Medical Sciences*, Jan., 1904). This form of pur-

pura with colic has been described and illustrated by many others and unreported cases occur in the records of most large hospital services. The four cases herein presented are of special interest from the standpoint of diagnosis and treatment.

CASE I.—A. F., referred by Dr. E. Payne, Riverhead, N. Y., Oct. 25, 1919. Girl, aged 5 years, born in U. S. of Polish parents. Family history negative. Past history represents patient as a delicate eater and has having had "stomach trouble" She developed petechiæ on arms and legs; this was followed by nausea and vomiting, pains in elbow, knee, and fingers, pain about the umbilicus, hemorrhages into skin of all parts of the body, epistaxis, hematemesis and melena.

Temperature, 98.8; pulse, 90; respirations, 18.

Physical examination at this time revealed a fairly well nourished child, anemic, with her hands clasping the umbilical region as in an effort to express intra-abdominal pain. There were scabs at the mucocutaneous junctions of her nose marking recent hemorrhages, and a suspicious spot on one tonsil; the submaxillary gland on one side was slightly enlarged; chest negative; tenderness and increased muscular resistance above and to left of umbilicus but no definite rigidity or localized tenderness; the stomach was distended with gas to the interspinous line; the liver palpable one finger below the costal border; the spleen was not palpated. No Kernig or meningeal signs were elicited.

November 10: Temperature, 102°; pulse, 90-100. Blood count: W. B. C., 10,000; polys., 70 per cent.; R. B. C., 1,700,000; Hgb., 72 per cent. Wasserman negative. Blood cultures negative. Urine: Albumin, 3 plus; blood in considerable amount; casts, hyaline and granular.

Dr. R. E. Stetson was called in consultation and the case placed under his care (Bellevue Hospital) for repeated transfusions, while repeated efforts were made to determine the possible existence of a focal infection. The child improved symptomatically for a short time after each transfusion, but after each of the five transfusions she inevitably relapsed until her exitus on Dec. 9, 1919.

Note in this case (1) the possibility of tonsillar

infection; (2) the persistent tendency to bleed and the prolongation of life by repeated transfusions; (3) the sequence of "spots," vomiting, joint pain, central abdominal cramp, and profuse hemorrhages from the skin and mucous membranes; (4) the absence at any time of a definite indication for surgical intervention.

CASE II.—C. S. Born in U. S. A. Aged 22 years. Female Admitted to Bellevue Hospital, May 26, 1920, with a history of having been treated for purpura hemorrhagica. In September, 1918, she was operated upon for acute suppurative appendicitis. The appendix was removed at that time and no untoward experience with bleeding was encountered. Symptoms on entry (1920) were nausea, vomiting, pain and mass in right lower quadrant. Examination confirmed hard, fluctuating mass in right iliac region, localized rigidity and tenderness. Blood count: W. B. C., 18,000, and 88 per cent. polynuclears.

At operation (May 27) hemorrhagic fluid was found in peritoneal cavity. Inflamed omentum and right parietes. Abscess to outer side of cecocolon. Acute phlegmon of cecocolon and enlarged mesenteric nodes from ileocecal region to root of mesentery. Technic: Amputation of cecocolon with distal end of ileum and proximal end of colon left in the lower and upper ends of wound, respectively.

Pathology: Thickened edematous cecocolon, termination of ileum, and appendix stump of 1.5 cm. Enterolith in stump (which may have ulcerated through giving rise to enterocolitis and abscess). Acute suppurative colitis.

May 29: Ileostomy.

June 10: Local condition satisfactory. Purpuric eruption over body and hemorrhages from nose and ileal stoma. Leucocytes, 75,000; differential count polys., 90; transitionals, 2; lymphocytes, 5, and myelocytes, 3. Blood culture negative. Wasserman negative. Transfusion (Dr. Stetson).

June 28: 3,200,000 red cells and 40 per cent. Hgb. Petechiæ over lower extremities. Prolonged profuse menstrual bleeding. Weight 102 pounds; 98 on admis-

sion. Transfusion (Dr. Stetson). Convalescence. Burke's Convalescent Home.

Sept. 17: Operation of enterocolostomy and removal of terminal ileal loop. Lateral anastomosis carried out as expeditiously as possible. The ileum was divided distal to the site of anastomosis and everted by attaching a rubber catheter within it and drawing on the

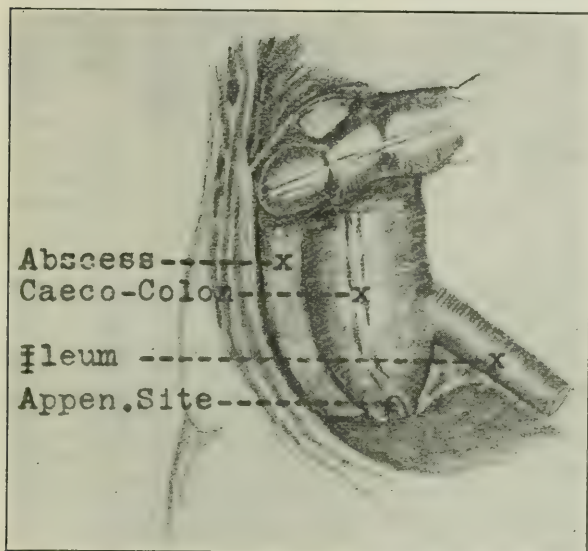


FIG. 1.—Case II. Illustrating the phlegmonous ileocolon and perforated appendix site, following an appendectomy 20 months before.

outside of the abdomen. The bleeding was profuse and uncontrollable, excepting by pressure and heat within the abdominal wall. Within the abdomen no difficulty with bleeding was encountered.

Sept. 20: Ileal loop ligated and on the following day excised.

Oct. 4: General condition satisfactory. Bowels

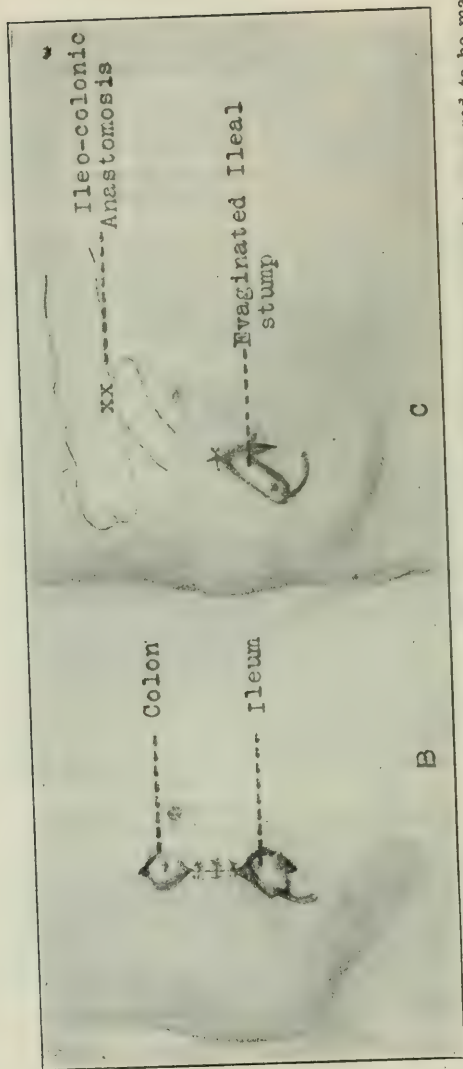


FIG. 2.—Case II. Showing colopexy and ileostomy following excision of cecocolon for what appeared to be malignancy (B); and final enterocolostomy and evagination of ileal stump (C). Although the transverse and descending colon were left unused and closed at proximal end for four months, this loop of colon promptly regained motor function after ileocolostomy. Hemorrhages decreased with improvement in the general condition of the patient.

moved from fourth day post-operative. Patient healed primarily.

May 2, 1921: Patient had been seen in interim and found in good condition; weight reached 120, and bowels moved spontaneously 1-3 times daily. She was admitted on the tuberculosis division of the hospital and succumbed on June 1 in the third stage of pulmonary tuberculosis.

Note: (1) bleeding history; (2) association of purpura with enterocolitis; (3) absence of purpura 3¼ months later but persistence of the "bleeder" tendency as manifested in operation for closure of ileostomy. Rapid convalescence within normal period; (4) final development of virulent pulmonary tuberculosis and exitus 2 years 9 months after first coming under observation.

CASE III.—M. R., U. S. A. Aged 30. Female. Admitted to Bellevue Hospital May 20, 1921. Illness began with acute onset of persistent vomiting and pain in upper abdomen. Abdomen generally rigid and tender. Urine negative. Blood: Leucocytes, 20,400 and 90 polys. The pronounced rigidity and continuous vomiting led to provisional diagnosis by the house staff of perforated gastric ulcer. Temperature normal. The acute abdominal signs responded so well to the usual preoperative morphine that the feeling arose that the patient might be suffering from mesenteric thrombosis or that the condition might not be surgical at all. At operation a recent hemorrhage of the subserous tissue of the mid-transverse colon was disclosed with purpuric spots on an adjacent loop of small intestine. This hemorrhagic tissue was dissected away and the abdomen was closed. The convalescence was normal, excepting for the nausea which was prolonged four or five days after operation. The microscopical examination of the tissue removed showed "fatty omentum infiltrated with blood."

Note: (1) absence of history of purpura; (2) sudden occurrence of serous hemorrhage without associated hemorrhages from the mucous membranes or skin; (3) the pronounced vomiting and

abdominal pain out of all proportion to the discoverable hemorrhage; (4) the abrupt disappearance of the symptoms and the untoward convalescence following the administration of morphine and laparotomy.

CASE IV.—A. L. Male. Age 46 years. Machinist. Born in Germany. Family history negative. For the past 10 years he has suffered from recurring attacks of dyspepsia. One month ago he tripped over a steam pipe 4 feet from the floor and passed bloody urine in the afternoon of the same day. The next day he vomited blood and the following three days passed bright blood from the bowels. He has had no other evidence of hemorrhage from the gastrointestinal or urinary tracts; no signs of bleeding into the skin or joints. This patient was not seen by me until four weeks after these acute symptoms. His medical advisers at the time of injury suspected gastric ulcer and proposed operation. No positive physical or laboratory findings persist at the present time, except an acute suppurative gingivitis. For the treatment of this condition and for the removal of this possible focus of infection the patient has been referred to a dental surgeon.

Note in Mr. L.'s case a similarity with Case II in that active suppurative foci exist in both in association with hemorrhage from the digestive tract. From experience with the above cases, and the purpuras occurring from time to time in routine practice, it appears that one has to be on his guard for surgical indications. In the cases above enumerated there may have been an indication for enucleation of chronically diseased tonsils before the first patient came under observation. A thorough clean-up of the pyorrheal condition was certainly called for in the fourth individual. The eradication of the infected material was obviously necessary in Case II, and investigation appeared to be indicated in the third case. The relationship

existing between the infectious process and its hemorrhagic manifestations is believed to be very suggestively shown in the second patient.

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616 MADISON AVENUE.

CHOLECYSTITIS; ITS RELATION TO INFECTION OF THE LIVER AND PANCREAS*

By W. HOWARD BARBER, M.D., F.A.C.S.
NEW YORK CITY.

From the Department of Surgery, University and Bellevue
Hospital Medical College, Prof. George D. Stewart, Director.

IT is well to consider the relationship of gall-bladder disease to inflammatory changes in the liver and pancreas because careful, systematic observations in cases of cholecystitis may lead to more detailed knowledge of the pathogenesis of hepatic and pancreatic diseases. Doyon¹ (1894) showed by direct experimentation that stimulation of the duodenal and gastric mucosæ gave rise to reflex contraction of the gallbladder and gall ducts and relaxation of the biliary sphincter and that such stimulation may travel through the afferent fibres of the vagus and backward through the sympathetic efferents. Oddi² (1895) pointed out that direct or reflex irritation within the nervous arc with its center in the first lumbar cord segment produced this same contraction of the bile passages and relaxation of the sphincter. Meltzer and Auer³ (1908-1909) noted duodenal relaxation including the opening of the Oddi sphincter and contraction of the bladder and ducts

* Read at the Annual Meeting of the Medical Society of the State of New York, at Albany, April 18, 1922.

following the application of magnesium sulphate to the duodenal mucosa about the papilla which phenomenon they explained under the "law of contrary innervation."[†] They realized that the vagus and sympathetic fibres, as Senior⁴ has maintained, are hopelessly intermingled below the diaphragm and that this magnesium sulphate reflex involved splanchnic dilation of the duodenum and vagus contraction of the bile passages. The status of this reflex bile-excretory test has evidently not become established, for Auster and Crolin⁵ report bladder retention and liver secretion during magnesium sulphate stimulation and Tsuji⁶ (after cholecystectomy) finds, in a series of human duct- and liver-fistulæ, bile similar to the duodenal bile following magnesium sulphate stimulation. Mann⁷ has reported a specificity of Dakin's solution (intravenously injected) for the gallbladder, by producing cholecystitis of severe grade within 24 hours. Hatieganu's⁸ tests have confirmed that after indigo-carmin has been injected intramuscularly it is recoverable in the bile from the duodenum in 20 minutes. Some such substance that would be opaque to X-rays should be an important aid to diagnosis of lesions of the bile tract.⁹ X-rays of the biliary ducts have been taken after bismuth or barium¹⁰ has accidentally passed into the ducts, and a few of these skiagrams have been reported. Attempts are made through chemical examinations of the blood for urea and glycogen and of the urine for glucuronic acid (Tollens Test) to throw light

[†] Sodium sulphate, sodium phosphate, peptone, one-tenth hydrochloric acid, bile, sodium glycocholate and even the mechanical trauma of a duodenal tube under certain conditions may stimulate a flow of liver bile.

upon the functional condition of the liver. On the other hand, a more direct approach to the actual condition of the liver substance has been made by Graham,¹¹ Judd,¹² and Ochsner (reported by Smithies¹³) in the removal of pieces of liver for microscopic examination from individuals being operated upon for diseases of the gallbladder. Duplications of this surgical investigation under experimental conditions has brought the added advantages of starting with a cholecystitis of known virulence, of removing liver sections from whatever part of the liver, and whenever one chooses, and of further controlling the extensions of the infection. Valuable clinical and experimental studies have been furnished by Deaver,¹⁴ Archibold,¹⁵ Graham,¹¹ Judd,¹² Mann,¹⁶ Sweet,¹⁷ Rosenow,¹⁸ and others. Good clinical histories undoubtedly remain the most valuable means of interpreting the gallbladder case, but the correlation with the history of reliable experimental observations in appropriate cases ought to increase our working knowledge of the liver and pancreas.

Emphasis has been given us by clinicians and by the experimentalists upon the finding of micro-organisms in the gall bladder, in the liver, or in the pancreas. From a review of the literature and personal communications dealing with the presence of bacteria in living tissues are the following: Dr. Theobald Smith¹⁹ writes that in order to obtain sterile animal tissues, it is necessary to kill the animals in the most quiet way possible in order to prevent the distribution or dissemination of bacteria from either the intestinal or respiratory tract or some more interior con-

cealed focus. His animals were always chloroformed when tissues were desired. He found unsterile tissues from animals that had been dispatched by direct violence. In 1902, Pease,²⁰ while Director of the Anti-toxin Laboratory of the New York State Department of Health, found that the tissues removed by him from animals killed by a blow on the head and cultured by the technic of Smith were invariably contaminated with bacteria and that the reverse was true after chloroforming the animals. Pease's studies upon the bacterial content of fish tissues convinced him that the same tissues showed greater bacterial growth during the height of digestive activity. W. W. Ford²¹ (1900) in "The Bacteriology of Healthy Organs" states "bacteriological examination of the organs was made in all cases, and the results were somewhat difficult to interpret. In many organs from which bacteria grew the forms isolated could be easily demonstrated in the section, especially mesentericus and staphylococcus. The blood vessels, as a rule, were filled with bacteria. In other cases, however, the only evidence of bacteria was the appearance, under the microscope, of many granules, both extracellular and intracellular, especially in the forms of cocci and diplococci, the number of these bodies being relatively great in the organs from which cultures were obtained as compared with a small number of granules seen in sterile organs, and practically none in the foetal. . . . But whatever be the explanation of the facts as a result of the experiments described in this article, it must be concluded that at least 80 per cent (80.6 per cent) of the livers and kidneys of

healthy normal animals contain bacteria which are capable of development, provided the proper culture media be adopted, and provided that these organs be cultivated for a sufficiently long time after their removal from the animals used." Meltzer²² reported the recovery of colon bacilli from the portal vein during health; Adami and several French observers²³ have declared that the circulating blood may contain many pathological organisms even in health. Investigations carried out in our own surgical laboratory with the co-operation of the Divisional Bacteriologist, Miss Barton, have shown the presence of bacteria in the blood aspirated from the mesenteric and portal veins and from the liver of an animal anesthetized over a period of two hours. The mere finding of bacteria in blood or tissues does not appear, therefore, to constitute in itself a diseased condition for, with proper technic, organisms are recoverable from individuals' tissues during health and during conditions of (traumatic and anesthetic) shock.

During infectious disease, it is generally agreed that the blood and bile may contain bacteria. A review of the pathology of seventy gallbladders removed on the third division, Bellevue Hospital, during the past two years shows infiltration of the walls with serum, leucocytes, or with pus in most every instance with or without ulceration of the mucosæ. Stones were found in 95 per cent of the 27 personal cases of this series. Rosenow and Rieman have reported the cultivation of bacteria from the walls of such gallbladders and conclude that the infection remains latent within the blad-

der walls. If this is so, the gallbladder that has once become infected remains (unless removed) a continuous source of re-infection of other tissues.

Obviously, bacteria may be carried into the liver by means of the blood, lymphatics, bile, or by direct extension. Ascending lymphatic infection of the liver was not demonstrated in the author's experiments upon transplantation of the bile duct as it developed in the pyelonephritis after urethral transplantations.^{23a} Bile cultures from bladders removed at operations are very often sterile. It seems probable that the portal-carried infection is the most common, for this channel accords with the finding during health and shock (as described above) and more logically explains the coincidence of cholecystitis with appendicitis, duodenal ulcer, splenic diseases, and other affections within the portal field. W. J. Mayo,²⁴ in his article on the hepatic cirrheses, writes: "Bacteria are constantly being carried to the liver from the portal circulation. . . . The spleen strains out many bacteria, as in typhoid, and protozoa, especially the plasmodium of malaria and the spirochete of syphilis: but it may be unable to destroy these organisms, and they are sent to the liver for destruction. . . . the liver, losing power to absorb and eliminate diffuse poisons, attempts to encapsulate them, thus introducing connective tissues" as seen in portal cirrhosis.

The gallbladder may be infected, as may the liver, through bacteria carried into it through the general circulation or bile, provided there is damaged tissue within the bladder to start bacte-

rial activity; but the evidence at hand appears to favor the lymphatic extension. Sappey²⁵ has represented these lymphatic connections between liver and bladder elaborately in his atlas, reproductions of which appear below. (Figs. 1-3.) Sudler²⁶ describes the lymphatics as "running over gallbladder . . . from the liver and the coats of the gallbladder. . . . They follow the inner side of the cystic duct and end in the mesenteric lymph glands." These lymphatics were shown to be involved, by reproducing calculus-cholecystitis. (See Experimental Table.) In the course of this work twenty-five animals were used. A foreign body to keep up mechanical injury was introduced into each bladder. Typhoid, faecal bacteria, or staphylococcus aureus were the organisms used to infect the bladders. Fig. 4. In three instances, the cystic ducts were ligated. In the great majority of animals, the lymph glands at the hilum of the liver, along the common duct, or about the pancreas were shown enlarged, as represented in the typical case below. Fig. 5. The sections taken across the ducts at the root of the liver and of the peripancreatic tissues revealed evidence of lymphangitis; and sections of the walls of the bladder and ducts, themselves, in a few instances, showed spaces closely resembling lymphatic channels filled with colorless fluid and leucocytes. Fig. 6. The livers of these animals in many instances showed demonstrable infiltrations of the periportal spaces with lymphocytes or polynuclears. Fig. 7. The organisms injected were in several instances recovered from the liver, and less frequently from the lymph nodes and from the pancreas. Gra-

ham¹¹ and Judd¹² agree that in every case of cholecystitis there is an associated hepatitis. The lymphatic route is suggested as the route of invasion of liver from a primarily infected gallbladder. Direct extension appears demonstrable occasionally (See experiments 62-64), but there is no apparent reason why infection should not follow the portal radicles (cystic veins) by way of the portal into the liver as in other infections within



1. (From C. Sappey) Showing arrangement of lymphatics on under surface of liver and gallbladder.

the portal region. From the liver, infection probably most often descends into the bladder and pancreas by way of the regional lymphatics. (Fig. 8.)

Pancreatic cirrhosis, according to Elizalde²⁷ and Lacoste,²⁷ is almost invariably associated with cirrhosis of the liver in the cadaver. Judd¹² reports thirty-one gallbladder cases with cirrhosis of the liver and, of these twelve had an associated pancreatitis. In the present series pancreatitis was believed to exist in eight out of thirty-two

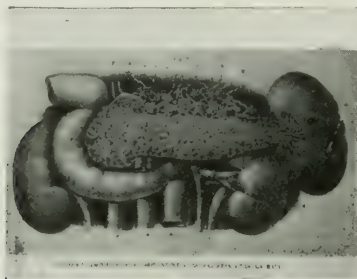
cases or in 25 per cent. (See table.) Chronic pancreatitis has been reproduced experimentally, in the animals of the series herein reported. The signs taken to denote "pancreatitis" in vivo: namely, enlarged pancreas or head of gland, "hardening," "more distinct lobulation," or "roughening" with or without enlarged lymphatic glands, were present. The microscopical picture



2. (From C. Sappey) Showing "Fig. 3" on section of liver the arrangement of the lymphatics within the portal canals. Portal vein infection, uncared for in the liver, can readily leave by the lymphatic efferents.

in this type of gland may show congestion or slight round cell infiltration or slight fibrosis but the epithelium remains intact. These findings are similar but much less marked than those found in the liver tissues of the same animals. This sort of pancreatitis is believed to characterize pancreatic lymphangitis, repeatedly described by Deaver, and to be the product of lymphatic-borne infection from the liver in certain of the cholecystitis cases.

The pancreatitis described by Flexner,²⁸ Flexner and Pearce,²⁹ and Opie³⁰ is more acute and involves the blood supply or secreting epithelium. This type of pancreatitis is met with occasionally after operations about the pylorus and duodenum as in pylorectomy, in the Polyas, or Bilroth 1 and 2 methods. It occurs very often following section through the first portion of the duodenum in the dog.³¹ The characteristics are fat necrosis,



3. (From C. Sappey) Showing the regional lymphatic nodes, some of which receive lymph from the liver by way of efferents accompanying the ducts within the gastro-hepatic omentum.

free hemolyzed blood in the peritoneal cavity and in the intestinal loops, and pancreatic cell necrosis. High intestinal obstruction and obstruction of the pancreatic ducts appear to be followed, in certain cases, by this form of pancreatitis. Judd¹² and Mann¹² have shown that 1000 mm. of bile pressure is necessary to produce pancreatic injury in the dog and that the possibilities for such a pres-

EXPERIMENTAL TABLE OF HEPATIC AND PANCREATIC CHANGES FOLLOWING

CHOLECYSTITIS (Incomplete)

Exp. No.	Duration (Das.)	Pathology in Liver	In Pancreas
1	4	congestion, acute culture positive	congestion, acute culture positive
2	1	necrosis, diffuse	negative
3	4	infiltration, periportal culture positive	necrosis
15	1	congestion, perilobular	negative
26	4	congestion; infiltration, periportal; choledochitis, acute	necrosis
28	7	infiltration, periportal pus; culture positive	normal culture sterile 72h.
29	7	congestion; ducts necrotic culture sterile 72h.	fibrosis culture sterile 72h.
30	7	ducts necrotic culture sterile 72h.	normal culture sterile 72h.
40	2	necrosis; ducts necrotic pus; bacteria undetermined	cholangitis
41	11	fibrosis; round cell infiltration; cholangitis, acute; culture positive	cholangitis, acute culture sterile 72h.
42	11	infiltration, periportal cholangitis, acute culture sterile 72h.	negative culture sterile 72h.
46	8	infiltration, diffuse; fibrosis; cholangitis, acute bacteria undetermined	not examined
47	6	congestion; culture positive	culture positive
51	6	cholangitis, acute culture positive	negative culture sterile 72h.
45	14	necrosis; infiltration; fibrosis	negative
62	10	necrosis; hemorrhage; infiltration	infiltration, peripheral
63	10	congestion; infiltration, periportal	normal
64	10	hemorrhage; fatty degeneration; cholecystitis continuous with hepatitis	normal

Note: Experiments of 1920 not included. Exps. 1-30 were infected with faecal bacteria; exps. 40-64 with staphylococcus aureus. Cystic ducts were ligated in 62-64. Cultures were taken as indicated above, only.

TABLE OF CONSECUTIVE HUMAN GALLBLADDER CASES PERSONALLY OPERATED UPON

Serial No.	Case	Age	Sex	Stones	PATHOLOGY IN ADDITION TO CHOLECYSTITIS	OPERATION
1	L. M.	26	F	Stones	Liver congested and enlarged	Cholecystostomy—C
2	M. H.	30	F	Stones	Ac. appendicitis, perf.; adhesions of intestine	Appendectomy
3	L. H.	46	F	Stones	Appendicitis, chr.	Relief of Adhes.—F
4	E. G.	24	F	Stones		Cholecystostomy—C
5	G. V.	44	F	Stones	Adhesions of pylorus	Cholecystostomy—C
6	L. S.	24	F	Stones	(Cholecystitis, ac., perf.	Cholecystostomy—C
7	I. T.	21	F	Stones		Cholecystostomy—C
8	L. L.	77	F	Stones		Cholecystostomy—C
9	G. J.	42	F	Stones		Cholecystostomy—F
10	Jde J.	32	F	Stones	(Glycosuria; acetoneuria	Cholecystostomy—C
11	E. F.	30	F		Pancreatitis, chr.	Cholecystostomy—C
					Salpingo-oophoritis, chr.	Salpingo-oophorectomy
12	A. M.	21	F	Stones	Appendicitis, chr.	Cholecystostomy—C
						Appendectomy
13	C. B.	65	F	Stones	Staph. aureus	Cholecystostomy—C
14	K. K.	49	F	Stones		Cholecystostomy—C
15	N. B.	13	F	Stones	Appendicitis, chr.	Cholecystostomy—C
						Appendectomy
16	A. W.	48	F	Stones	Hernia, Umbilical	Cholecystostomy—C
					Oophoritis, chr.	
					Fibroma uteri	
17	J. F.	56	F	Stones		Cholecystostomy—C
18	J. E.		F	Stones		Cholecystostomy—C
19	M. S.	34	F	Stones	Appendicitis, chr.	Cholecystostomy—C
						Appendectomy
20	H. T.	20	F	Stones	Cholecystitis, ac., perf.	Cholecystostomy—C

24	I. R.	60	F	Stones	Pancreatitis, chr.	Cholecystectomy—C
p25	E. D.	51	F	Stones	Pancreatitis, chr.	Cholecystectomy—C
p26	A. L.	66	F	Stones	Fibroma uteri	Cholecystectomy—C
p27	L. K.	32	F	Stones	Carcinoma of stomach	Gastrectomy
p28	L. L.	25	F	Stones	Pancreatitis, chr.	Cholecystectomy—C
29	MON	60	F	Stones	Glycosuria; hyperglycemia	*Cholecystostomy—F
30	R. S.	39	F	Stones	Pancreatitis, ac., perf.	Drainage
31	B. M.	53	F	Stones	Pancreatitis, ac.	Cholecystectomy—C
32	F. B.	26	F	Stones	Appendicitis, chr.	Appendectomy
					Hernia, Ventral	Cholecystectomy—C
					Pancreatitis, Chr. (?)	Herniotomy
						Cholecystectomy—C

Note: Cases observed in group..... 32
Cholelithiasis in 31
Other inflammatory lesions in..... 10
Carcinoma of stomach in..... 1
Liver noted enlarged in..... 2
Pancreatitis, chronic, in (?)..... 7
Pancreatitis, acute, in..... 1
Total..... 73

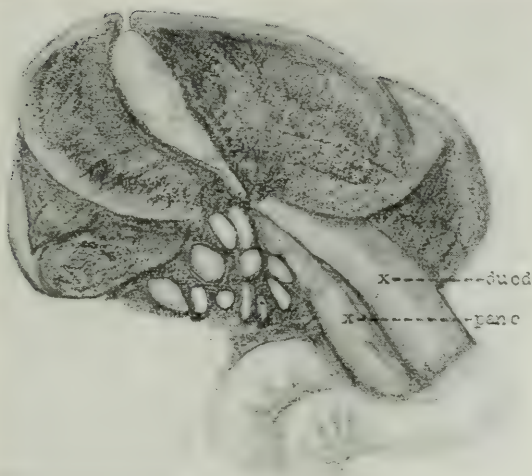
Fatalities after cholecystectomies..... 1 in 25 or 4.0 per cent.
Fatalities after cholecystostomies..... 0 in 6 or .0 per cent.
Total mortality, excluding ac. pancreatitis..... 1 in 30 or 3.3 per cent.

* One case of acute pancreatitis for which cholecystostomy was done succumbed two weeks after operation.



4. Acute experimental cholecystitis. Note pus to right, necrosis of mucosa at centre, and compare with high power of wall.

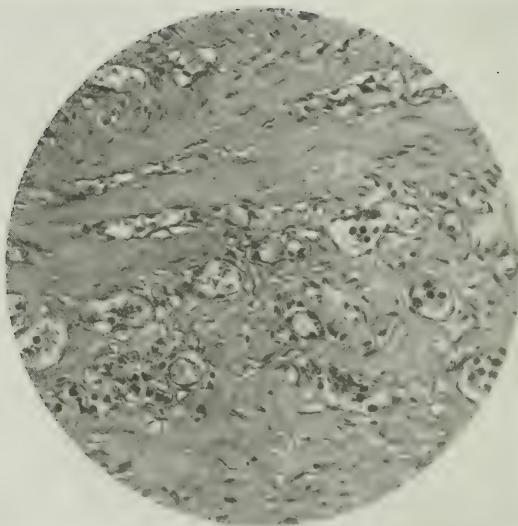
sure arising are not great in that common duct and pancreatic duct obstruction (which is necessary to maintain such high intrabiliary pressure) appeared possible in but 4.5 per cent of 170 human autopsies. Archibald holds that pathologic bile is more injurious to pancreatic tissue than normal bile (partly because the irritant salts are relatively increased over the mucoid constituent of the bile) and that the relative bile salt increase combined with the toxins is responsible for many



5. Drawing from autopsied animal showing enlarged glands at hilum of liver and about pancreas. (Liver, duodenum, and pancreas drawn upward and outward.)

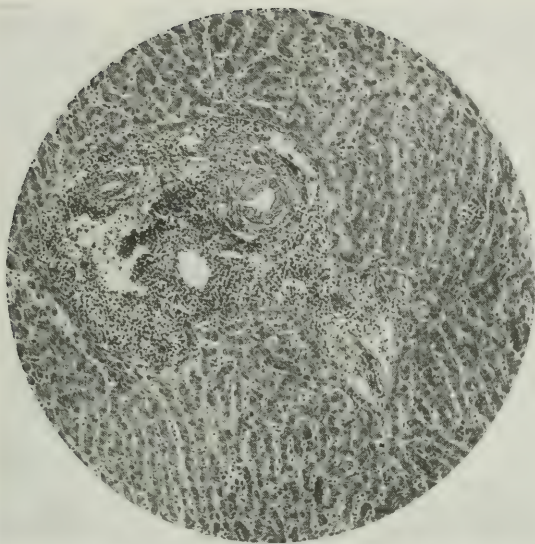
instances of pancreatitis accompanying the gall-bladder cases.

One sees all grades of pancreatitis with cholelithiasis. It is probably impossible to definitely trace the course of the infection from the gall-bladder and liver into the pancreas, once it has occurred. The presence of pathologic glands along the common duct and at the upper border of the pancreas would seem to argue in favor of lymphangitis: the absence of lymphadenitis and the acute signs of severe pancreatitis may point toward bile-carried infection.



6. Submucosa of gallbladder of experimental cholecystitis, showing dilated vessels resembling lymph spaces containing leucocytes and colorless fluid.

The condition of the bile ducts in the experimental series varied from normally appearing ducts to acute suppurative cholangitis; but the most frequent finding was catharrhal cholangitis. (See Fig. 9.) This was based upon sections taken at different levels of the hepatic radicles and bile ducts. On this point, Poppert³² says that his clinical observations lead him to believe that the colicky pains that frequently occur after

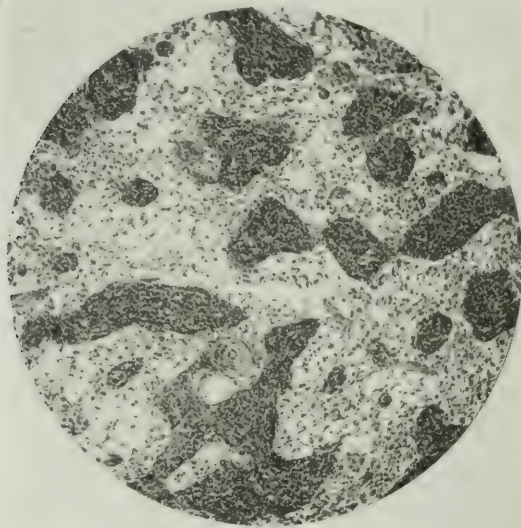


7. Periportal infiltration following experimental cholecystitis. Bile duct fairly well preserved.

operation on the bile tracts cannot be due solely to adhesions, but that an infectious cholangitis or cholangiolitis plays a part. We have noted intermittent temperature in some and a persistent rapid pulse with no temperature* in others, without obvious reasons to account for them, that we have felt due to infection within the liver substance. One is tempted to believe that there is a small percentage of clinical cases corresponding

* Rising pulse and falling temperature often follow excessive loss of bile.

to the small proportion of experimental cases in which the cholangitis is suppurative and the excretory products are slowly emptied out through the larger ducts. In such cases as these, convalescence may be relatively prolonged, abnormal



8. Lymphadenitis from a duct-gland in acute experimental cholecystitis.

temperature and pulse-temperature relationships may occur or the duct spasm, described by Poppert, may conceivably arise.

The conclusions arrived at from a comparative study of a hospital series of gallbladder cases,

from a series of intentionally produced cholecystitis in animals, and from a review of the literature are that hepatitis is very often associated with cholecystitis, that the infection travels by way of the portal blood, that the liver receives bacteria from the portal field in health and dis-



9. Section across bile ducts at hilum of liver in acute experimental cholecystitis showing degree of cholelithiasis.

ease, that infection leaves the liver by way of the lymphatics and gives rise to pancreatic lymphangitis relatively often, and that infection is carried through the lumen of the bile ducts relatively infrequently.

From a practical surgical point of view, it is suggested (1) that cholecystitis, once, be regarded as cholecystitis, always, in that latent infection remains within the bladder wall, (2) that cholecystectomy be the operation of choice when the diagnosis of cholecystitis is made (in the absence of definite contraindications), (3) that drainage, preferably through the cystic duct, be instituted at once in proper cases, (4) and that absorbable ties (chromicized gut) be used for the cystic stump to facilitate spontaneous drainage for relief of excessive intraduct pressure.

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The pancreatic factor in intestinal obstruction.

By H. B. EISBERG.

[*From the Department of Experimental Surgery, University and Bellevue Hospital Medical College, New York City.*]

In a previous communication¹ some experiments on the pancreas in relation to intestinal obstruction were reported. This presentation includes a duplication of the work with additional data. Twenty-three dogs were used. The experiments were divided into five groups.

Group I: Duodenal occlusion, pancreatic occlusion,² number of dogs, 5.

Average duration of life, 76.6 hours. Observations: A mild toxæmia developed which did not stimulate the toxæmia of duodenal obstruction. Autopsy revealed a slight congestion of the duodenal and colon mucosa. Microscopic examination of the pancreas³ showed a capillary congestion, nuclei indistinct and the ducts filled with secretion.

Note: An accidental traumatic pancreatitis and a partial devitalization of the oral duodenum was responsible for a severe toxæmia in two of these cases. These variables were not included in estimating the mean duration of life.

Group II: Duodenal occlusion, partial pancreatic resection (duct bearing portion), number of dogs, 3.

¹ Eisberg, H. B., *Annals of Surgery*, 1921, lxxiv, 584.

² Sweet, J. E., Peet, Max M., Hendrix, B. M., *Annals of Surgery*, 1916, lxi, 720.

³ Fraser, A., Personal communication.

Average duration of life, 43.3 hours. Observations: The symptoms of duodenal obstruction were greatly accentuated owing to the associated pancreatitis. Autopsy revealed a congestion of the peritoneum, also a slight congestion of the duodenal and colon mucosa. Fat necrosis was present in each case. Microscopic examination of the pancreas showed a hæmorrhagic infiltration with cells in different degrees of auto-digestion.

Group III: Duodenal occlusion, pancreatic excision, number of dogs, 5.

Average duration of life, 70.3 hours. Observation: The severity of the toxæmia of duodenal obstruction is greatly diminished when the pancreas is excised. Autopsy revealed a slight congestion of the mucosa of the duodenum and terminal colon.

Note: A severe toxæmia occurred in two cases; the result of general peritonitis in the one and partial devitalization of the duodenum in the other. These variables were not included in estimating the mean duration of life.

Group IV: Duodenal occlusion, pancreatic excision, pancreatic transplant (auto), number of dogs, 4.

Average duration of life, 29.7 hours. Observation: A severe toxæmia developed within a few hours, the result of devitalized tissue produced by the digestion of the bed of the pancreatic transplant. Autopsy revealed congestion of the peritoneum duodenal and colon mucosa from a slight to a moderate degree.

Group V: Ileal segmental exclusion; bilateral occlusion; reconstruction of intestinal canal; pancreatic tissue (homo) placed within isolated segment^{1 2}; number of dogs, 6.

Average duration of life, 35.7 hours. Observations: A severe fulminating toxæmia developed within 18 hours. Autopsy revealed a devitalized segment. A rupture of the segment was found in three animals with resulting fat necrosis and peritonitis.

Note: In one animal the segment remained viable. The resulting toxæmia stimulated duodenal occlusion. The duration of life was 72 hours. This variable was not included in estimating the mean duration of life.

Surgery of the Heart; Blood-Vessels; Thrombosis and Embolism and Blood Transfusion.

BY

Charles GOODMAN, M. D., F. A. C. S.

Clinical Professor of Surgery,
New-York University and Bellevue Hospital Medical College, New-York City.

In the treatment of injuries of the bloodvessels from projectiles of war, the more conservative surgeons of our armies have preferred ligature to suture as being more expeditious and better adapted to the casualty clearing stations and the hurriedly arranged and rapidly shifting hospitals of the front.

The advanced surgeons in our ranks, however, have performed suture operations when there were no absolute contraindications, such as a high degree of sepsis, extreme laceration of the vessel or exhaustion from hemorrhage. But, by the conservative attitude of the majority of our surgeons, our armies lost, in my belief, the great benefits that might have been derived from the suture methods of Carrel, Tuffier, and their followers. As in the instance of Marshal Foch's work on strategy, we ourselves armed our enemies from the forges of our intellect. I must confess that I personally was directly responsible in the matter, as while in Germany in 1913, I was asked to instruct a class of Professor Stich's pupils in the latest American technique of blood-vessel suture. I feel relieved to note, I may add in parentheses, that Fromme, one of the class, does not seem to have profited much by my teachings, if I may judge from the report of his operations.

The bulk of the German reports was not accessible, to my great regret, but the most complete review of war aneurysms by Salomon,

who collected 642 arteriovenous aneurysms by 196 operators, shows that out of 275 ligatures, 68.7 per cent were cured, with 31.3 per cent gangrene. In the 185 sutures there were 78.3 per cent of recoveries, only 21.7 per cent of gangrene. The mortality was the same for both methods, 9 per cent. Salomon gives the following detailed tables of 460 of these cases :

Location of blood-vessels.	No. of Cases.	Treatment.						
		Ligature				Suture		
		Central.	Peripheral.	Central and Peripheral with Extirpation.	Central and Peripheral without Extirpation.	Lateral	Circular.	Venous graft.
Head	34	2	5	11	4	6	4	2
Neck	52	»	7	14	5	15	8	3
Upper extremity.	171	1	3	86	7	32	35	7
Lower extremity.	203	13	9	94	14	41	26	6
		275				185		

The foremost German advocates of suture were, besides Rehn, from whose hospital Salomon made the report given above, Bier, Enderlen, Küttner, Hotz, Coenen, Hans, Jeger, Pribram, Moschowitz, Sehrt, Gebele, Lexer, Stich, von Verebely, Vollbrecht and Wieting, Steinthal, and Hans von Haberer, who had only one failure out of 140 cases of suture.

Von Haberer at the beginning of the war leaned towards ligature as the more practical method of treatment in the advanced areas, but afterwards became a convert to suture. He reports over 200 cases.

Graf, Riedel, Seedorff, Zoega v. Manteuffel, Goldhammer, Bornhaupt, Brentano, Hartleib, von Frisch, Rumpel, Gobiet and Riedinger report cases treated by ligation, but the conclusion of Rehn and von Haberer that suture is to be preferred in all vascular injuries seems to have been shared by most of the Central European operators.

Before I went over to the British Expeditionary Forces, I took care to provide myself with a number of gold tubes for the method of arterial intubation suggested by Dr. Théodore Tuffier. I had read M. Tuffier's article in the *Bulletin de l'Académie de médecine de Paris*, of 1915, describing this tube « with extremely thin walls silvered over and dipped in paraffin » which, when passed into an artery, assures the permanence of the circulation for a considerable time. My experience with the tube showed the usual success in cases where more than

one-half of the circumference of the vessel had been severed, where portions of the wall of the vessel had been destroyed; or where local infection or the exhausted condition of the patient did not permit the transplantation by suture of the saphenous vein. The tube possesses the great advantage of bridging the gap due to retraction of the severed ends of the artery, and thus, by its gradual occlusion, of permitting the re-establishment of a greater collateral circulation.

Tuffier has repeatedly broken a lance for vascular suture and transplantation as not only the ideal but the more practical method. He lays particular stress on the injunction to resort to lateral suture in all the cases in which the form of the lesion permits it. Piollet, Marquis, Pauchet, Grégoire, Toupet, Gaudier, Patel, Lannois Soubbotitsch and others have reported successful cases of suture while Mauclair's reports indicate that he performed suture whenever possible. De Tarnowsky of the Service de Santé advocates suture as the ideal operation and considers that its indications have been greatly extended.

Professor Sencert in his work on « Wounds of Blood-vessels » concludes that ligation of the vessel is « the method *par excellence* for vascular wounds, and that indications for suture are exceptional ». He is followed by Alamartine, Duval, Soubeyran, Quénu, Bousquet, Arnaud, Barthélemy, Dupont, Dambrin, Venot, Charbonnel, Chevassu, de Vaucresson, Péraire, Laurent, Buguet, Villandre, Garrigues, Coudray, Blanc, Fredet, Roulland, Autefage, Derache and Voncken. Many operators are convinced that ligation of the satellite vein should be done after the ligation of the artery involved.

The British Surgeons, led by Sir George Henry Makins, are in favor of ligation, and contrast the simplicity of ligation with the many difficulties of suture. Bishop, Cowell, Heath, Pybus, Ball, Grange, Mac Ewen, Pearson, Swan, Symonds, Whiteford, Bland-Sutton, Whale, White, Brown, Tubby and Bannister, Nicoll, Ballance, Davidson and Scott and Mac Lachlan report ligation cases. Pearson performed Matas' operation several times, and suture successes are reported by Marnoch, Morrison, Wright and Preston.

When I was at the British front for a month in 1917, the surgeons there then believed that ligation of the vessels of the lower extremities — the femoral, popliteal and even the posterior tibial, — were invariably followed by gangrene. The injury to anyone of these arteries was therefore considered sufficient to justify an immediate amputation of the extremity to avert the danger of rapidly spreading gas infection and impending death. During my stay with the British Expeditionary

Forces, it was my good fortune to have five consecutive instances of suture of the vessels of the extremities which enabled me to refute the deductions made by the other surgeons present.

In the group of five cases here presented, wounds of the vessels repaired by suture showed an early and satisfactory restoration of patency, and gangrene from an insufficient blood supply was thus warded off.

CASE 1. — Mc K., G., private, age 28; November 10, 1917. Suture of the popliteal artery and vein. Examination showed a through-and-through shell wound of the left popliteal space. The hamstring muscles were badly lacerated. The clots were wiped from the wound and sharp bleeding followed. The popliteal vessels were exposed and the artery and vein were found lacerated. The bleeding was controlled by a Jeger clamp and a longitudinal opening measuring 5 millimeters in each vessel was closed with a continuous silk suture. A flap of muscle was fastened over the line of suture for greater protection. After excising all the lacerated muscle, the edges of the upper two-thirds of the wound were approximated with silkworm-gut sutures and a Carrel-Dakin dressing applied.

A tract of a shell wound on the right forearm was excised. On November 12, 1917, 48 hours after operation, the foot was found warm, the dorsalis pedis artery was perceptible, the pulsation being normal. The upper angle of the wound showed evidences of retention and the sutures were removed. On November 14, the Carrel tubes were discontinued, the wound was « bipped » and dressed with paraffined gauze.

November 18, 1917, the wounds of the leg and the arm were clean. The pulse and temperature was normal; the dorsalis pedis and posterior tibial arteries were pulsating vigorously.

The post-operative temperature during the first week varied from normal to 101° F., and the pulse from 88 to 112. November 19, 1917, the patient was transferred to the Base Hospital.

CASE 2. — L. E. L., private, age 23; November 13, 1917. Suture of the popliteal vein. On examination, a shell wound was found on the right hip, and another on the right leg. The popliteal vein was partially severed. A longitudinal rent 12 millimeters long in the vein was sutured and a foreign body was removed from the soft parts. « Bip » was applied to the wound with a light packing of paraffined gauze.

A tract in the buttock was excised, the foreign body removed, and « Bip » and paraffined gauze dressings were applied.

November 18, 1917, the wounds were found clean and the patient was removed to the Base Hospital; November 23, the patient wrote that he was doing well.

CASE 3. — Mc L., A. G., private, age 26; November 17, 1917. Suture of the femoral vein. On examination a shell wound was found in the right thigh in the region of Scarpa's triangle. The internal saphenous vein was found severed. Profuse bleeding from the depth of the wound was found to be due to injury of the femo-

ral vein. A rent 20 millimeters long in the femoral vein was sutured. The Esmarch's bandage was then removed and bleeding was found to proceed from a tributary with three distinct perforations. Ligature of this tributary checked the bleeding. The contaminated tract was excised and Carrel-Dakin tubes and dressings were applied.

November 22, 1917, the wounds were found clean; no oedema, temperature and pulse normal. The patient was transferred to the Base Hospital.

This patient wrote to me on December 14 that he was able to get out of bed. On December 19 he was able to walk about 3 miles from the Hospital to the village.

CASE 4. — F. W., private, age 31; November 20, 1917. Suture of the femoral vein. Shell wound of right and left thigh and buttocks. The perineum, scrotum and both testicles were lacerated and the left testicle was completely destroyed. Profound shock. Hypodermoclysis with glucose and sodium bicarbonate was administered. Suture of the two large rents in the right femoral vein controlled the bleeding completely. Much damaged muscle was excised, the crushed left testicle was removed, the right testicle was repaired by suture and replaced in the scrotum. The wounds of the buttocks and left thigh were cleansed and the lacerated muscles excised. Carrel-Dakin dressings were applied, and hypodermoclysis and proctoclysis administered at regular intervals.

November 21, 1917, the condition of the patient was much improved.

November 22, 1917, pulse 96; temperature 100° F. The patient was transferred to the Base Hospital.

Report from Base Hospital: General condition very anemic and septic. November 30, there was hemorrhage from the right femoral artery. The artery and vein were ligated below the profunda; this was followed by transfusion of blood. December 4, there was gangrene of the foot which required amputation of the lower third of the leg.

CASE 5. — P. T., private, age 21; November 25, 1917. Suture of the popliteal artery. Through-and-through shell wound of the left thigh. A large oval opening (1 1/4 cm. long) was found in the popliteal artery just below Hunter's canal. The artery was sutured and the calibre of the lumen was reduced to one-half its normal size. The tract of shell wound was excised, a branch of the femoral vein was ligated, and all the damaged muscles were excised. A flap of the fascia lata was removed and fastened over the line of suture in order to protect the latter from erosion by the Carrel-Dakin tubes used in the dressing.

November 26, 1917. The highest post-operative temperature was 99.4° F, pulse 76. The circulation in the limb was very satisfactory. The patient was transferred to the Base Hospital.

December 12, 1917. The patient wrote that he was getting on well, that he had no pain, and that the Carrel-Dakin tubes had been discontinued.

In support of suture, Professor Mario Donati states that as two-thirds of his cases of popliteal vessel ligatures resulted in gangrene, end-to-end suture as well as lateral suture are incomparably better, because

even if the vessel's lumen is gradually closed up by thrombosis, the process is so slow that an effective collateral circulation has been re-established. Donati also used Tuffier's tubes with success. Chiasserini concludes that suture is preferable, given a certain experience in vascular surgery in the operator and asepsis for the operation. Negroni believes in suture, but does not think transplants are practicable in war surgery.

Bastianielli performed sutures in an interesting series of cases, but the ranks of ligature adherents include Della Torre, Ferrarini, Perassi, Stretti, Campora, Mantelli, Marinacci, Caucci, Gilberti and Matera.

Among the Americans, Carrel, Bernheim and Dorrance are suture advocates and performed a number of operations which have not yet been reported owing to the pressure of their other scientific work. Ashhurst has also reported several successful cases of suture (1).

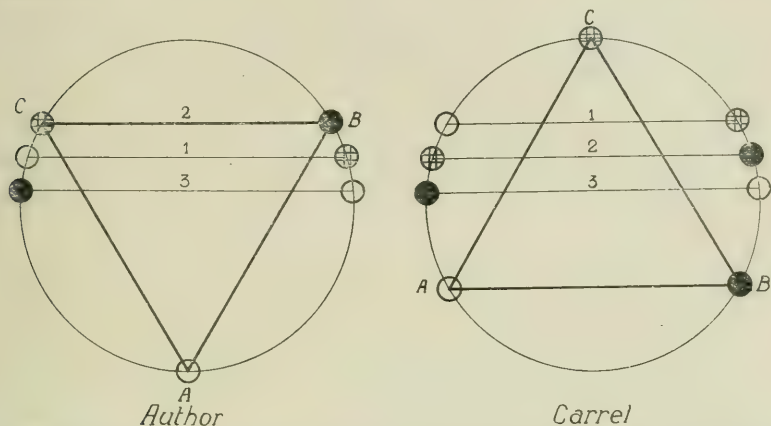
The mention of *mon cher maitre*, Alexis Carrel recalls the technique of end-to-end suture. He introduced primarily three stay-sutures after having freed the severed ends of the vessel from its adventitia. Bier has attempted to modify this technique by the employment of two mattress stay-sutures introduced into the opposite sides of the walls of the vessel. The eversion of the vessel wall by such procedure has the disadvantage of impeding its histological reconstruction. A slight modification of the Carrel technique which I reported in 1914, on the other hand, permits the circular suture to be completed with a minimum amount of twisting of the vessel.

The third side of the triangle with Carrel's method is made accessible for suture only by twisting the vessels for a distance of 180 degrees. By introducing the first retaining stitch on the posterior side so that the triangle formed by the three retaining stitches will have its apex downward, it was found that the vessels were twisted only for an arc of a quarter of a circle, or 90 degrees. The importance of this feature of the technic is particularly emphasized in an attempt to anastomose the shorter vessels.

By the approximation of the severed ends of the vessels by the simple overhand continuous circular suture, the histological reconstruction of the vessel wall can be established so perfectly as to allow the muscle cells to grow into the almost invisible cicatrix. (See Illustration no. 1.)

(1) Owing to the delay of Congress in making the appropriation for the compilation of the statistics of the American Expeditionary Forces much work of interest was not available which might have been embodied in this report.

When a vessel is completely severed, the severed ends will retract for several centimeters. I have observed that if at least three points in the peripheries of the severed ends can be approximated by stay sutures, the vessel becomes relaxed and this tendency to retract is immediately overcome. The danger of the sutures cutting out is considerably lessened.



A, first retaining and traction suture, also starting point of circular suture; *B*, second retaining and traction suture; *C*, third retaining and traction suture. Lines 1, 2 and 3 (left figure) indicate the relative position of the corresponding sides of the triangle during the suture by Carrel's method. Lines 2, 1 and 3 (right figure) indicate the relative position of the corresponding sides of the triangle during the suture by author's modification.

The frequency of the wounds of the vascular system was far greater in this war than in any previous one. This may be accounted for by the fact that missiles of high velocity which were so extensively used in this war did not permit the recoil of the blood vessels. In previous wars, the comparative scarcity of blood vessel injuries was accounted for by this peculiar physiological phenomenon. Furthermore, the use of shrapnel, hand grenades and other high explosives caused much destruction of the blood-vessels as the jagged missiles tore the vessels.

Leriche observed that a vessel hit by a blunt missile may pass into a chronic state of tonic contraction with complete obliteration of the pulse, which may be permanent or last for some time. Leriche has practiced perisymphatotomy for this condition (*stupeur artérielle*) with most gratifying results.

Burroughs has shown that paresthesia of the glove and stocking type may be entirely due to a vascular lesion without concomitant injuries to the nerves.

Babinski and Heitz made similar observations, and Desplats and Bouquet found that sensory disturbances were more frequent in the upper limbs than in the lower, although less in degree. The limb is atrophied but oedematous towards the periphery. The nerves have lost their direct excitability, but have not lost their conductivity.

In my opinion the dangers of secondary hemorrhage following suture have been exaggerated. Another erroneous idea is that heavy sutures are necessary. I have used a suture of raw silk of a tensile strength of no more than two ounces in the suture of the femoral vessel in the human being as well as the aorta in dogs, and have not yet seen a single instance of hemorrhage due to the giving away of the suture.

The presence of a mild infection in the operative field should not deter the surgeon from suture of the vessel provided there is drainage of the overlying wound. Paraffined or vaselined gauze or rubber tissue lend themselves best to this purpose. Tuffier agrees with me on this point.

The Carrel-Dakin solution may be used as a dressing in the presence of infection without fear of dissolving the silk sutures. The silk sutures are covered with remarkable rapidity rendering them proof against the solvent properties of the solution.

That arteries may be plastically reconstructed has been proved experimentally and clinically even before the proof accumulated in the literature of war surgery from 1915 to 1920.

In my own experience at Base Hospital No. 3 of the American Expeditionary Forces, I operated upon an arterio-venous aneurysm of the femoral vessels in the upper portion of Scarpa's triangle. A shell wound was found to have passed through the femoral artery and carried with it a portion of the anterior wall of the profunda at its point of junction with the femoral. The profunda was ligated and the posterior wall of the stump of the artery was used to cover the defect in the femoral as is shown in the illustration. A large rent in the femoral vein was closed by a lateral suture. The patient developed sepsis from an osteomyelitis due to a tangential fracture of the under surface of the pubic bone which had not been revealed by the X-Ray examination.

The specimen removed showed patency of the sutured artery without any evidence of thrombosis. (See Illustration No. 2.)

As Carrel, Morestin, Villard and others discussed the subject of transplantation at the last session of the Congress, I shall only touch briefly upon this aspect of blood-vessel surgery.

In regard to the question of transplantation of segments of vein,

Illustrations I,V,VI taken from the
author's collection of specimens of
work in the surgical laboratories at
the College of Physicians and Surgeons
Columbia University, New York.

a University, New York.
 type of physicians and dentists
 the medical literature of
 a collection of specimens of
 which I have been from the

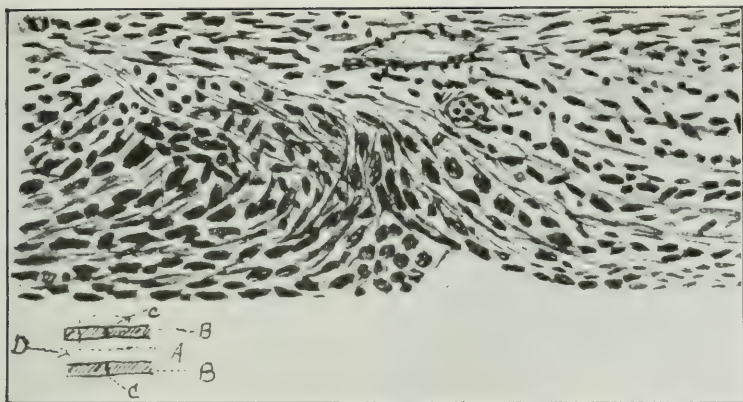


ILLUSTRATION No 1. — Drawing. End-to-end suture of carotids.

Operation January 20, 1916. Specimen removed February 9, 1916. Cicatricial tissue firmly unites one vessel end to that of the other. One extremity is slightly everted and the other is implanted upon it. The recess is so obliterated by connective tissue that the intimal lining is completely regenerated. The suture line is hardly discernible on account of the merging of the cicatrix with the sutured ends. Smooth muscle cells as demonstrated in a Van Gieson stain grow into the cicatrix.

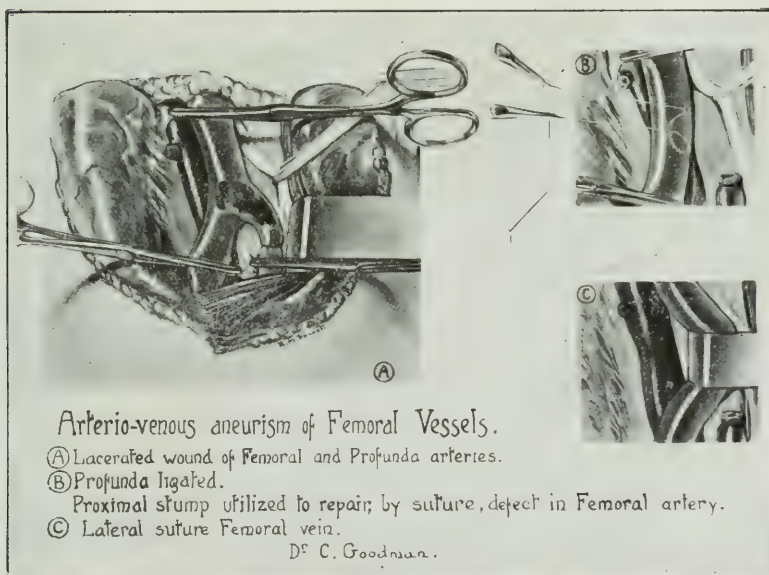


ILLUSTRATION No 2.

there is ample laboratory and clinical evidence that such transplants become dilated but remain dilated for a time only. They become hypertrophied, and eventually are able to withstand increased blood pressure and to perform the functions of an artery. The operation is not adapted to surgery at the front, but it is of immense practical value at Base Hospitals in restoring the circulation of an extremity, as we see from the results of 47 cases published by Warthmüller in 1917, in which there were forty successes.

Neuhof and Herrick have shown the value of connective tissue transplants in the repair of the vessels. Like many other surgical methods, a preliminary laboratory experience will obviously prepare the surgeon for a rapid and successful suture operation.

TRANSFUSION.

It is pleasant to remember that the first transfusion practised upon man was made by Jean-Baptiste Denys, the Court Physician of Louis XIV.

From 1667 we must proceed to 1906 before another Frenchman, in whom we Americans feel we have a half-share, *mon cher maitre Carrel*, revived interest in transfusion by his remarkable blood-vessel work. This operation of direct transfusion by means of vessel suture was so brilliant in technique that few could venture to imitate it, so that Crile's simplification with the cannula was a boon to the profession at large.

Buerger, Elsberg, Levin and Soresi tested the cannula with varying results. Brewer suggested the paraffined glass cannula. Frank, Bernheim and Lespinasse did good work, while Lindemann obtained remarkable results with his syringe.

Lindemann required three assistants, however, which suggested to Unger the device of the three-way stopcock requiring only one assistant.

Curtis and David, Vincent, Kimpton and Hooker and Satterlee further modified the indirect method by the use of communicating tubes and ampoules of greater calibre and capacity, which did away with the necessity of attaching the donor to the recipient. These ampoules were lined with a paraffin coating in order to avoid coagulation. The drawback of this method was the tediousness of coating these tubes with paraffin and the necessity of having several ampoules at hand on account of breakage.

Experiments were made by Agote of Argentine, Weil, Lewisohn and Houston to see if anti coagulants added to the blood would delay coagulation sufficiently to permit of its transfer without impairing its chemical and biological properties.

Sodium citrate was found better adapted than hirudin on account of its non toxicity in quantities sufficient to render the blood non-coagulable until the transfusion was completed. It was also proved that sodium citrate does not injure the blood corpuscles.

These investigations made the technique of transfusion so simple that the possibilities of its universal application became at once apparent.

Moss in 1911 had done away with the lengthy tests to determine the compatibility between the blood of the recipient and that of the donor. He found that all individuals fall into four groups as regards the hemolytic and agglutinative qualities of their blood.

GROUP I (10 per cent) : Sera agglutinate no corpuscles. Corpuscles agglutinated by sera of Groups II, III and IV.

GROUP II (40 per cent): Sera agglutinate corpuscles of Groups I and III. Corpuscles agglutinated by sera of Groups III and IV.

GROUP III (7 per cent) : Sera agglutinate corpuscles of Groups I and II. Corpuscles agglutinated by sera of Groups II and IV.

GROUP IV (43 per cent) : Sera agglutinate corpuscles of Groups I, II and III. Corpuscles agglutinated by no serum.

The following table shows the relation of the four groups with respect to agglutination :

		Serum.			
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
I	(10 per cent)	0	+	+	+
II	(40 per cent)	0	0	+	+
III	(7 per cent)	0	+	0	+
IV	(43 per cent)	0	0	0	0

The red cells of Group IV are agglutinated by no group. Therefore, in war work, it is best to employ only Group IV donors, in which case the patient's blood does not need to be tested.

Moss demonstrated that the absence of agglutination precludes the possibility of hemolysis and evolved a simple, rapid and sufficiently accurate method for practical purposes.

Vincent practically dispensed with laboratory equipment in his macroscopic test for agglutination. His technique is as follows: A drop of Group II serum is placed at one end of a clean microscopic slide and a drop of Group III at the other end. A small drop of blood from the person to be tested is mixed with a match stick with each drop of serum. The end of the match is broken off between the drops in order to avoid mixing the sera. The slide should be often tipped from side to side during the test. A positive test shows definite clumping within a few minutes which can be discovered with the naked eye. A negative test remains as a smooth film.

Robertson suggests that if Group II and Group III sera are not to be had, the patient's serum may be tested directly against the cells of the prospective donor or donors. A small amount of blood is collected from the patient, one cc. from the ear or the finger, and allowed to clot. Usually, at the end of 15 or 20 minutes, sufficient serum will have collected for the test, which is performed like that of Vincent. An absence of agglutination indicates compatibility.

During the war, donors were chosen from patients either convalescent or with slight wounds and who had no history of either syphilis, malaria, or trench fever. Hemorrhage is, of course, the chief indication for transfusion and the latter is absolutely necessary when the blood count falls to 1,000,000 red blood cells and 20 per cent hemoglobin. De Page found that when the red cells decrease below 4,500,000 in 3 hours, 4,000,000 in 8 hours, or 3,500,000 in the first 12 hours, only transfusion can save the patient's life. Govaerts agrees with De Page.

Reactions.

Hunt reports that in a series of 726 transfusions by the sodium citrate method performed on 301 patients of the Mayo clinic, there occurred in 18.7 per cent a frank reaction, characterized by chill and fever, nausea and vomiting, urticaria and severe headaches. The percentage of reactions in the pernicious anaemia cases was 23.3 per cent as compared with 14.8 per cent in other conditions. There were seven cases in which a donor from a wrong group was used; in two of these cases the patients died, but all the others recovered. Bernheim reported 800 cases with hemolysis in 15 cases, with four deaths. Pemberton insists on the fact that the injection of incompatible blood in large quantities (500 ccm.) is almost invariably fatal.

With the objections to modifications of blood with sodium citrate eliminated, owing to the simplification of technique, and with the absence of increased risk, the transfusion of citrated blood has become the method of choice.

Technique.

An aspirating needle thrust into one of the superficial veins of the donor suffices for the collection of the blood into a bottle containing several cc. of 2.5 per cent of sodium citrate. The blood having been collected, an aspirating needle is then thrust into one of the superficial veins of the recipient. When this is impossible, on account of collapse of the veins, a cannula introduced under local anesthesia through a small incision exposing the vein will overcome the difficulty.

Helmholtz has found that in infants the blood may be given through a needle thrust into the superior longitudinal sinus by way of the anterior fontanelle.

Among the British surgeons, Archibald, Wallace and Bruce Robertson used transfusion in a considerable number of cases. Giraud and Hedon performed interesting experiments which stimulated Jeanbrau to use in May, 1917, a solution of sodium citrate within a modified Kimpton-Brown tube with a capacity of 500 cc.

The experimental work of Peyton Rous and Turner at the Rockefeller Institute in the early years of the war has shown that blood cells could be preserved for some time in a solution of dextrose and sodium citrate.

Robertson's method of preserved blood cells enabled the war surgeon to hold in reserve for four weeks a supply of red blood cells for the time of great need. The method requires experienced laboratory workers, and it has the same effect as that produced by the transfusion of whole blood.

In 1913, Hogan proposed the use of colloidal gelatin solution in shock, but it proved useless for medical service abroad. Bayliss of the British Army and Cannon of the American Forces, advocated gum acacia as a substitute, and in order to meet the incidence of acidosis due to shock, 3 per cent sodium bicarbonate was added to the solution.

Many accidents after transfusion with this agent caused our army to almost abandon it.

Ashby in a series of agglutination tests undertaken to discover the

reason for the benefits following citrate transfusion, found that transfused red cells remained alive for about 30 days in the recipient's blood.

We may therefore conclude with him that the sodium citrate transfusion not only increases the blood bulk and stimulates the hematopoietic organs, but also actually increases the number of red blood cells for the space of a month.

The Committee on Transfusion of the United States Army Medical Corps of which Lieut. Col. Burton J. Lee was Chairman adopted the sodium citrate method for the front hospitals as the simplest one that gives absolute satisfaction. A so-called « shock team », consisting of an officer of the medical corps, his assistant, a nurse and two enlisted men of the Medical Corps, was sent to the respective advanced operating centres. This team performed all the transfusions of blood or its substitutes upon the wounded as they came in. A member of the staff in all hospitals was assigned to the preparation work of transfusion. His duties were: (1) To provide continually an adequate number of donors who had been properly grouped. (2) To group all donors and recipients. (3) To be available for consultation with any of the hospital staff concerning transfusion. (4) To perform or direct personally all transfusions at the hospital. (5) To supervise all transfusion records in order to add information on the subject with clinical and laboratory data. (6) To instruct other men assigned to transfusion work.

In conclusion, there are two points which I should like to particularly emphasize. The first point is the practical specificity of blood transfusion in the treatment of hemophiliac conditions of the newborn. These infants are usually brought to the hospital in a condition of extremis one or two days after birth by a member of the family. The procedure which is usually followed is to dispatch a member of the house staff to the home of the mother and to withdraw about 100 cubic centimeters of her blood in a sterile container with sufficient citrate of soda to make a 0.25 per cent solution. This citrated blood is promptly introduced into one of the veins of the infant or into the superior longitudinal sinus via of the anterior fontanelle. This method has proved a cure in the majority of instances.

Cherry and Langrock have shown conclusively that the mother's blood is compatible with that of the infant's for the purpose of transfusion during the first six weeks of life. This dispenses with the delay incident to blood grouping.

The second point which I desire to emphasize is the use of the professional donor. Since the scope of the clinical application of blood

transfusion, has become widened we we have found the so-called professional donor almost indispensable. These donors will, for a certain fee, permit the withdrawal of a specified quantity of their blood. They are carefully examined for evidences of contagion and their blood classified according to the groups to which they belong. The addresses of several of these donors and their grouping are posted in the laboratory of the hospital so that in the event of an emergency calling for a transfusion, one of these donors belonging to the proper group is sent for and the transfusion performed without delay.

SURGERY OF THE HEART.

Heart surgery began with Farina's first case of cardiorrhaphy in 1896, though Bloch, in his study of cardiac wounds in the lower animals was the first to suggest the operation for the human being. Villar, Guibal, Loison and Guinard reported cases, and Salomoni in December, 1906, had collected 160 operations on the heart with 62 recoveries.

Wounds of the heart were sutured in 134 cases, with 49 recoveries; foreign bodies were removed in 5 cases with five recoveries. In 128 cases compiled by Lenormand in 1906, the mortality was 36.7 per cent. Vaughn in 1909 found a mortality of 65 per cent in 150 cases. He reported 14 American cases, with 6 recoveries.

Several years before the war, I had in my hospital service a case of stab wound of the heart in a man of 46. An hour after the injury had been inflicted I operated, exposing the heart by an intercostal incision, and entered the pericardium through the pleura. The hemorrhage was controlled, but the patient died a week afterwards from sepsis incident to a suppurating pleuritis which I attribute to the drainage of the pleural cavity.

Vaughn had also concluded that the evidence is against drainage of the pericardium and pleura. While intratracheal and intrapharyngeal methods of anesthesia have materially diminished the dangers of pneumothorax, the opening of the pleura remains an extremely serious operation. My failure in the case just mentioned leads me to search for a

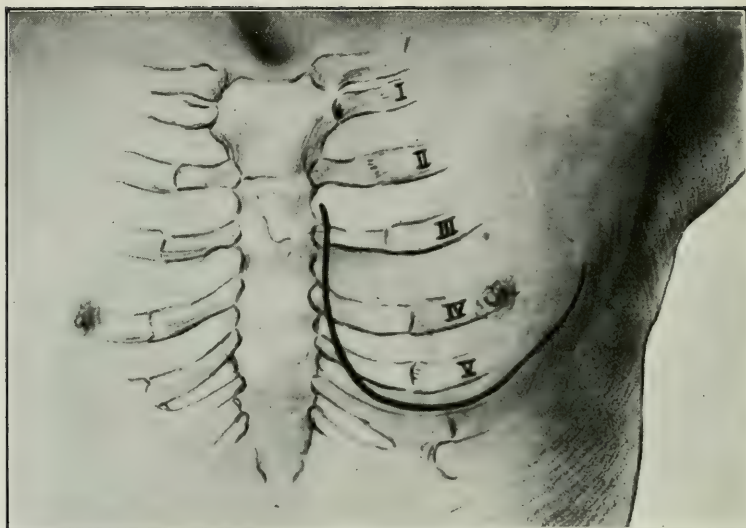


ILLUSTRATION No. 3.

Outline of incision of thoracic wall for exposure of the pericardium.

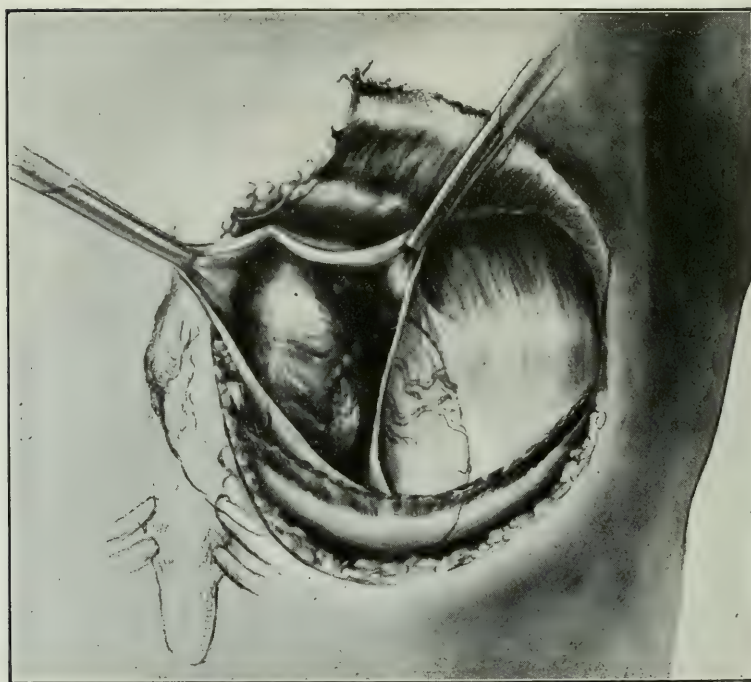


ILLUSTRATION No. 4.

Triangular flap of thoracic wall raised. The pericardium incised longitudinally affording free access to the heart. The parietal pleura separated by blunt dissection from the anterior wall, remains unopened.

method of exposure of the heart which will eliminate this factor of danger. I have evolved the following operation on the cadaver, and believe it to be a perfectly practical procedure.

An intercostal incision is made in the 3rd, 4th or 5th interspace, down to the pleura; the pleura can usually be separated, bluntly, with the fingers from the anterior wall. McBurney's division of one, two or three cartilages close to the sternal margin after ligation of the internal mammary artery exposes the pericardium. The pericardial sac is then lifted and incised between mousetooth forceps for any desired extent without encroaching upon the pleural cavity. (See Illustrations No. 3 and No. 4.)

This exposure gives a ready access to all parts of the heart without incurring the dangers of a pneumothorax or pleuritis. It also permits a practically bloodless division or resection of the sternum with any degree of exposure of the mediastinum.

In Vaughn's collection of 150 cases, 16 gunshot wounds were operated upon with a mortality of 56 per cent, or 10 per cent lower than other kinds of wounds treated by cardiorrhaphy.

Rehn collected 15 cases with 6 recoveries (40 per cent).

War surgery has remarkably increased the evidence of the toleration of bullets and other foreign bodies by the heart, a fact commented upon by Fischer, Loison, Salomoni, Elten, Morestin, Schloffer and Kharkoff.

Eccles writes of a patient who walked a mile and a half to the Hospital at Ypres after he was wounded by a bullet in his right ventricle which he tolerated perfectly for five months afterwards. Delorme and Delbet observed that in the initial clinical pictures of such cases the patient appears dazed and syncopal and complains of retro-sternal constriction and dyspnoea on the slightest exertion. Mental anxiety, arrhythmia and irregular amplitude of the cardiac pulsation are also present. In the later stages, the missile may be almost perfectly tolerated.

Escarde and Brocq in their 14 cases from French literature have shown that in 5 the tolerance was nearly perfect. The dyspnoea and precordial pain, though severe at first, gradually subsided in most cases. Delbet records the removal from the right ventricle of a cube-shaped irregular piece of steel about $1\frac{1}{2}$ cm. in periphery. Delorme in his compilation of 17 cases, notes that in 10 cases, the projectiles were lodged in the right ventricle, three in the right auricle, two in the left ventricle and one in the left auricle. There were 10 recoveries and 7 deaths.

Le Fort removed 11 foreign bodies from the heart in nine operations

— in two cases from the cavities. Only one patient died — all the others were cured.

Among the surgical curiosities of the war is the migration of bullets or shell fragments from the heart to the great vessels or *vice versa*.

Grand Gerard reports a case in which the bullet traveled as demonstrated by the screen from the level of the right auricle to Scarpa's triangle. Two days later it was located in the hypogastric vein and fixed by ligating the vein. Gregory's patient was wounded on January 9th and the bullet was located by the X-ray as it moved upward and inward in the thorax with respiration. On January 18, a diagnosis of haemothorax was made and aspiration performed. Two days later the X-ray located the bullet in the abdomen one inch to the right and one inch below the umbilicus. On January 26, symptoms of appendicitis set in. The bullet was lodged behind the peritoneum on the inner side of the ureter and presumably in the internal iliac vein. The patient died of peritonitis. In Lyle's case, the foreign body in the right ventricle of the patient was only discovered at the autopsy.

THROMBOSIS AND EMBOLISM.

The secret of suturing blood-vessels and retaining the normal continuity of the lumen is to render the operative field as free as possible from thrombokinas. If the suture is contaminated with ferment, thrombosis will be produced. (See Illustration No. 5.)

After Virchow noted that thrombi show greater richness in white blood corpuscles and in granular material than the postmortem clot, Montegazza in 1869 stated that a white thrombus at its inception consists of white blood-corpuscles, which after a short time break up into a mass of granules identical with fibrin in their reactions. Osler reported the observation of human thrombi composed almost entirely of blood platelets, and Hayem found that the thrombi formed in wounds of arteries are made up of blood platelets.

Welch described in 1887 the mode of formation of thrombi as follows: Given suitable conditions, such as alteration of the vessel wall, slowing and irregularity of the circulation, the first constituents of the thrombus to accumulate are the blood platelets. In the course of time leucocytes

are present in such a quantity that they must be considered an essential constituent of the completed thrombus. With the increasing accumulation of leucocytes, the conditions for the coagulation of fibrin appear and fibrillated fibrin is deposited. The final result is a plug composed of platelets, leucocytes, fibrin and red blood corpuscles.

Welch continues : « As regards the relation between changes in the walls of the vessels and thrombosis, it is possible to produce experimentally severe injury of the internal coats of blood-vessels without any resulting thrombosis. Slowing of the circulation and irregularities of the circulation produced by abnormalities in the lumen of the blood-vessels are factors no less important in the production of thrombi than alterations in the blood-vessel walls. »

Aschoff believes that thrombi are essentially produced by some mechanical obstruction or slowing of the blood stream, and that the bacteria which are found in them are brought to the thrombus after it is well formed.

Mac Callum holds that many thrombi arise because an injured or dead surface is exposed to the coagulable circulating blood, as in the sclerotic patches of the aorta, the infected lateral sinus in otitis media, the uterine veins in puerperal sepsis, or the portal branches leading away from an appendicular abscess. Or bacteria may lodge on the endothelium of a valve in a vein where the current is vastly slower, and there, by injuring the endothelium, make possible the first step in the formation of a thrombus.

Injury to the endothelium seems to be of a prime significance to Mac Callum, and Keen agrees with him in the main.

Angus Mac Lean in 1914, deprecated this stress on endothelial damage as a cause of thrombosis and advanced the theory that the main contributory causes are a low-grade infection (not of sufficient virulence to be noted clinically), and slowing of the blood stream. These factors are found in the greatest percentage of cases that are followed by thrombosis. Mac Lean drew his conclusions from a large clinical experience of 1310 laparatomies and from Schenck's reports of 3252 myomectomies.

For some time many of the Allied surgeons were of the opinion that the hypochlorite solution was responsible for the erosion of the vessel in the frequent secondary hemorrhages seen in this war. But this supposition was refuted by the evidence that the hemorrhages appeared at a point some distance from the wound area treated by hypochlorite. I am

convinced that these hemorrhages are due to a bacterial invasion of a thrombus occluding a lateral injury in the vessel wall, which is followed by a necrosis of the vessel from contact with the infected thrombus at some distance from the original wound. The streptococcus haemolyticus infection is followed by sequestration of the necrotic vessel wall. As the sequestrum is formed, it blows out and is accompanied by profuse hemorrhage.

In view of the uncertainty prevailing as to the process of thrombosis, Matthews' inquiry into the function of the endothelium of blood-vessels arouses lively interest. Matthews in his «Physiological Chemistry» advances the theory that the function of the endothelium is probably not passive since it certainly plays a part in the coagulation of the blood. «It must be constantly interacting with the blood, changing its composition, possibly affecting its viscosity, controlling the secretion of lymph and possibly constituting hormones of importance to the body. Does it take fibrinogen out of the blood and put it in? If it controls the viscosity, as its relation to clotting implies, how does it do it? Is it by shedding fibrin ferment? By secreting enzymes specifically suited to the blood proteins?». Matthew concludes that all these questions must be answered before we can solve the riddle of thrombosis.

From this rapid review, it may be seen that the theory of thrombosis is still unsolved. As long as conjectures rule as to the factors on which thrombosis depends, modes of treatment must remain tentative.

But when a thrombus has formed, steps can be taken to avoid its most dangerous complication — embolism. Mac Lean advises that the limb should be raised to encourage the venous circulation, and kept warm, wrapped in cotton and surrounded by hot water bags. Absolute rest must be maintained for from 3 to 4 weeks until the clot has become thoroughly organized. If the patient escapes the embolism, Mac Lean points to the gloomy late histories of Schenck in which 63 per cent of the patients never fully recovered.

In my early experimental work upon animals, I had noted several times that injuries to the intimal lining produced by the careless application of the compression clamps was not followed by thrombosis. The breach in the intima was soon found to be covered over with smooth endothelial lining.

Though injury of a blood-vessel is usually followed by thrombosis, the thrombosis is not necessarily occluding unless the vessel has been completely severed. An injury not involving the entire circumference is more likely to be followed by an accretion extending for a distance, at

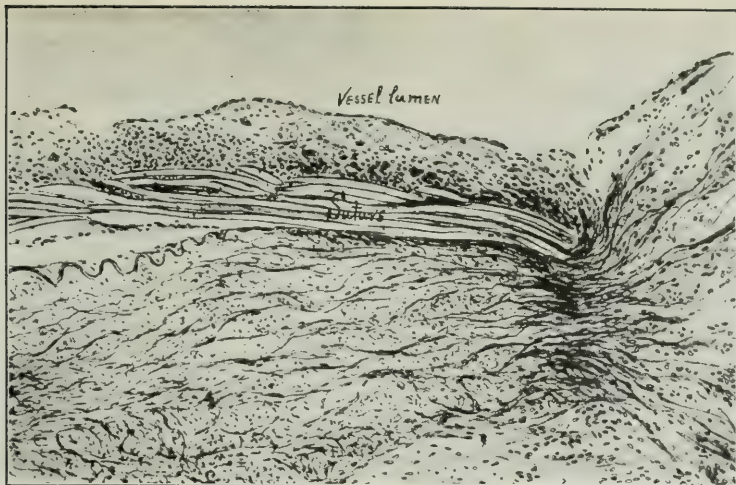


ILLUSTRATION No 5. — End-to-end suture of carotid.

Operation, November 13, 1915. Specimen removed November 22, 1915. Sutured ends separated by $\frac{1}{2}$ mm. of connective tissue on one side; on the other side by 2 mm. This connective tissue at some points is dense; at other points it is loosely constructed. The intima regenerates everywhere. At one point, one of the sutures lies within the vessel lumen, and is completely covered by connective tissue, with an endothelial surface. Where there was wide separation of the vessel ends, there is a considerable mass of relatively loose connective tissue on the surface which is covered with intima. In the depths the repaired vessel wall is dense and suggests osteoid structures. In the depths of the suture line at another point, very definite osteoid structure exists. There is a distinct dilatation of the lumen at the site of the suture line.

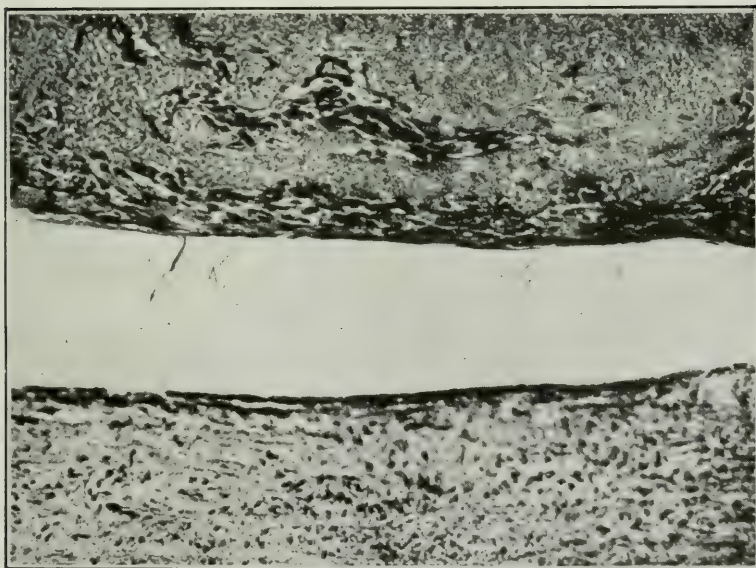


ILLUSTRATION No 6. — Autotransplantation of vein into carotid.

Operation January 3. Specimen removed January 17. Vessel partially occluded by coagulum. Surface of coagulum presents connective-tissue cells and apparently no accretion has taken place. Blood coagulum covered by growing fibroblasts also infiltrating coagulum. No further tendency for blood to form a clot in the coagulum which presents a smooth surface as shown here.

times, as much as five or six centimeters along the vessel wall. Such a thrombus may present at the end of a few days, a smooth surface not unlike that of endothelium in appearance. (See Illustration No. 6.)

Suture : other injuries.

Location.	Number of Cases.	Method.		Gangrenes.	Deaths.	Recoveries.
		Circ.	Lateral.			
Carotids	9	»	»	»	»	9
Subclavian . . .	1	»	»	»	»	1
Axillary	1	»	»	»	»	1
Brachial	3	»	»	»	1	2
Femoral	4	»	1	»	»	4
Popliteal . . .	4	»	»	»	»	4
TOTAL	22	»	1	»	1	21

Operators : Cowell, Enderlen, Kappis, Rehn, Grégoire and Goodman.

Ligation : other injuries.

Location.	Number of Cases.	Gangrenes.	Deaths.	Recoveries.	Notes.
Carotids	24	»	5	19	
Subclavian	7	»	2	5	
Axillary	3	»	2	1	
Iliac	4	1	»	3	
Femoral	5	1	»	4	
Popliteal	1	»	»	1	
TOTAL	44	2	9	33	

Operators : Makins, Antefage, Murard, Croisier and Mauclair, Riedinger, Ferrarini, Roulland, White, Fredet, Peraire, Scott and Mc Lachlan, Gilberti, Ritter, Barnsby, Brau-Tapie, Davidson, Blanc, Condray, Garrigues and Lefevre.

Comparative results.

SUTURE AND LIGATURE.

Suture.	Number of Cases.	Cures.	Gangrenes.	Deaths.	Notes.
Aneurysms . . .	236	226	7	3	
Transplantation .	12	11	»	»	1 sec. hemorrhage;
Other injuries . .	20	19	»	1	1 improvement.
					1 oedema.
TOTAL	268	256	7	4	
Ligature.					
Aneurysms . . .	337	296 (1)	30	11	(1) 1 motor paraly-
Other injuries . .	44	33	2	9	sis; 1 spastic pa-
					ralysis; 1 hemi-
TOTAL	381	329	32	20	plegia; 1 disorder
					cervical plexus;
					1 oedema; 1 para-
					lytic symptoms.

Transplantations.

Location.	Number of Cases.	Recovery.	Other Results.	Notes.
Femoral	6	5	1 improvement.	
Axillary	1	1	»	
Brachial	1	1	»	
Popliteal	2	2	»	
Iliac	1	1	»	1 oedema, slight
Subclavian	1	1	»	swelling.
TOTAL	12	11	1	

Operators : Coenen, Henle, Sehrt, Hauber, Lexer, Bier and Kuttner.

Aneurysms : suture.

Location.	Number of Cases.	Method.		Gan-grenes.	Deaths.	Reco-veries.	Notes.
		Circ.	Lateral.				
Carotids	20	5	11	»	1	19	
Subclavian	28	8	17	»	2	26	
Axillary	32	18	10	»	»	32	
Brachial	19	6	8	»	»	19	
Cubital	2	»	1	»	»	2	
Tibial	2	»	»	»	»	2	
Iliac	13	6	6	1	»	12	
Femoral	86	14	36	3	»	83	
Popliteal	34	14	17	3	»	31 (1)	(1) 1 sec. hemor.
							1 sl. oedema.
TOTAL	236	71	106	7	3	226	

Operators : von Haberer, Donati, Basti inelli, Preston, Klapp, Rychlick, Jedlicka, Kojen, Soubbotitsch, Lewit, Bier, Gjurgewitsch, Slajiner, Kertitsch, Bauer, Gronenberger, Orhan Bey, Morison, Mauclore, Denk, Hauber, Lexer, Patel, Alary, Sencert, Gaudier, Toupet, Willems, Grégoire, Bier, Gobiet and Chutro.

Aneurysms : ligation.

Location.	Number of Cases.	Gangrenes.	Deaths.	Cures.	Notes.
Carotids	31	2	2	27 ⁽¹⁾	(1) 1 motor paralysis: 1 spastic paralysis, 1 hemiplegia, 1 disorder of cervical plexus.
Subclavian . . .	38	7	4	27	
Axillary	34	2	»	32	
Brachial	34	»	1	33	
Cubital	1	»	»	1	
Radial.	6	1	»	5	1 oedema.
Iliac	4	»	»	4	
Femoral	112	12	4	96	
Popliteal . . .	46	6	»	40	
Gluteal	4	»	»	4	
Tibial.	21	»	»	21	1 paralytic symptoms.
Maxillary . . .	1	»	»	1	
Temporal. . . .	5	»	»	5	
TOTAL	337	30	11	296	

Operators : von Haberer, Tubby and Bannister, Buguet, Sinclair, Oudard, Sencert, Guisepppe, Villandre, Saigo, Kikuzi, Brentano, Bornhaupt, Zoege v. Manteuffel, von Frisch, Subbotitsch, Orhan Bey, Goldhammer, Coenen, Laurent, Vollbrecht and Wieting Pascha, Péraire, Willis, de Vaucresson, Wright, Patel and Lannois, Maclaure, Quenu and Delbet, Chevassu, Charbonnel, Dambrin, Venot, Brown, White, Hartleib, Fowelin and Idelson, Lexer, Matera, Mally, Dupont, Forsdike, Barthélemy, Bier, Gobiet, Legneu, Chutro and Moncany and Legendre.

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EFFECTS PRODUCED ON BLOOD PICTURE BY OXYGEN INFLATION OF PERITONEAL CAVITY *

CHARLES GOODMAN, M.D.

Clinical Professor of Surgery, University and Bellevue Hospital Medical College; Surgeon, Beth Israel and Montefiore Hospitals

NEW YORK

Our attention has been directed of late to roentgenograms of the abdominal organs in which the outlines were brought out by the use of oxygen inflation of the peritoneum. Last fall I decided to make use of this technic, and began by making several peritoneal inflations in my service at the Beth Israel Hospital. Credit for the original idea of the use of oxygen as an aid in roentgen-ray diagnosis of the abdomen must be given to Kelling. His views were published in 1902. The method received little or scant attention until Jacobaeus took it up eight years later, and he was followed by several others. Stewart and Stein again discussed the procedure. They state that if the peritoneum is distended with oxygen, the gas will be absorbed within twenty-four hours. This is contrary to my observations. Dr. Charles Gottlieb and I have observed that, while much of the gas may be absorbed within twenty-four hours, the presence of some of it can be demonstrated with the roentgen ray for two weeks after the injection. Before introducing the oxygen into the peritoneal cavity, I decided to observe what effect 1,000 or 2,000 c.c. of oxygen would produce on the blood picture of the subject when introduced into the closed cavity of the peritoneum. I had observed in five patients at the Beth Israel Hospital in whom the peritoneal cavities were inflated with 1 or 2 liters of oxygen that the number of erythrocytes was increased from 80,000 to several hundred thousand after the oxygen inflation. The oxygen was introduced into the peritoneal cavity through a cannula passed

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through the abdominal wall. I found that the injection of more than 1 or 2 liters caused unnecessary discomfort to the patient. Our first case was a postoperative empyema.

RESULTS OF FURTHER INVESTIGATIONS

As the results were so gratifying, I followed these observations with similar ones on some of the chronic invalids of the Montefiore Hospital. About 1,000 c.c. of oxygen were injected into the peritoneal cavity in two cases of splenomegaly and in a case of inoperable carcinoma of the stomach. The two cases of spleno-

TABLE 1.—RESULTS OF INFLATIONS

Cases	Red Blood Cells		Net Increase in Red Blood Cells
	Before Injection of Oxygen	24 Hours After Inflation	
1. Postoperative empyema.....	4,000,000	4,080,000	80,000
2. Tumor of kidney.....	3,960,000	4,800,000	840,000
3. Suspected ulcer of stomach.....	4,000,000	5,600,000	1,600,000
4. Subphrenic abscess.....	3,680,000	4,160,000	480,000
5. Pelvic tumor.....	5,730,000	6,260,000	530,000

TABLE 2.—RESULTS OF INFLATIONS IN CHRONIC INVALIDS

Cases	Red Blood Cells		Net Increase in Red Blood Cells
	Before Injection of Oxygen	24 Hours After Inflation	
1. Splenomegaly.....	3,326,000	6,200,000	2,870,000
2. Splenomegaly.....	4,400,000	6,030,000	1,630,000
3. Inoperable carcinoma.....	6,280,000	6,000,000	320,000

megaly gave positive Wassermann reactions. The results of these inflations are shown in Table 2.

EFFECT IN PERNICIOUS ANEMIA

We also observed results in a case of the fatal form of pernicious anemia. The patient's red blood cell count was only 480,000, and the count made twenty-four hours after the peritoneal cavity had been inflated showed a net increase of 1,680,000, or a total of 2,160,000. I have not been able to find similar reports by others.

POSSIBLE MECHANICAL EFFECT

I believe that the results of our observations may be due to the mechanical effect of the pressure of the gas

on the larger abdominal venous trunks. Some support to this contention is given by the results obtained several weeks ago by Dr. Max Kahn, who performed some animal experiments for me in the laboratory of the Beth Israel Hospital. Pneumoperitoneum produced in six rabbits inflated with oxygen showed in each of the six rabbits injected a net increase of from 200,000 to 900,000 red blood cells. He then inflated the peritoneal cavity of three rabbits with nitrogen gas, and the results were similar. The blood taken from these rabbits showed an increase in the red blood cell count of 200,000, 300,000 and 500,000, respectively.

THERAPEUTIC SIGNIFICANCE

I am not prepared at this time to make any statement as to the value of this procedure as a therapeutic measure. I have no direct evidence that oxygen introduced into the closed peritoneal cavity has any direct stimulating effect on the hematopoietic organs and therefore I am not prepared to suggest that the method might be utilized in the treatment of anemia. On the other hand, my observations lead me to believe that the gas acts as a splint by giving support and pressure to the larger venous trunks of the abdomen and thus might be utilized in the treatment of shock.

CONCLUSION

As far as I have gone, I have concluded that oxygen injected into the peritoneal cavity is followed by an appreciable increase in the number of red blood cells in the peripheral circulation, which is demonstrated by the blood count. Further experiments will be undertaken with a view to determine definitely the value of this measure.

969 Madison Avenue.

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ANNALS OF SURGERY

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USE OF CHINOSOL AND SODIUM CHLORIDE AS A FIRST AID

DR. WILLIAM C. LUSK presented a series of patients to demonstrate the value of first-aid disinfection of civil wounds by chinosol and sodium chloride solution. He said that it seemed of significance that, out of a series of twelve experiments on dogs, in which wound pockets constructed in the subcutaneous tissue without blood infiltration, were treated first by filling with certain chinosol-salt solutions (which procedure caused lymphatic infiltration), and then by packing with gauze saturated with the solutions for fifteen minutes, before the scientific infection was instituted (the object being to create a lymphatic block with the disinfectant solution, which should completely envelop the aftercoming bacteria, having used for the infection as much of a virulent culture of staphylococcus aureus as could be absorbed on a piece of gauze about half an inch square, which had been rolled into a wad, placed in the bottom of the wound for half an hour), and then following the scientific infection, by again packing the wounds with gauze saturated with the solutions for fifteen minutes and finally suturing the wounds up tight, in seven instances primary union resulted while the control wounds suppurated with staphylococcus aureus (ANNALS OF SURGERY, May, 1919, p. 493).

It also seemed of significance that, in the case of a sterile wound pocket opened up through a three-inch long incision in the subcutaneous tissue of a dog's back, without blood infiltration, whose lymphatics had been first infiltrated with $\frac{3}{4}$ of a solution of 2 per cent. chinosol and 0.85 per cent. sodium chloride, which formula was that of the first-aid solution used for the past year and more, and the wound itself then packed with gauze saturated with the same solution, which was left in place for forty-eight hours, at the end of the latter period of time the gauze was found to be no more than slightly damp with moisture, and tightly adherent throughout the wound and was pulled free without causing the slightest hemorrhage, while the surface of the wound had a parched appearance and crinkled when its tissues were picked up with a forceps. The wound was thereupon again washed with the first-aid solution and sutured, the skin having been disinfected again with McDonald's solution before the packing was removed, with resulting primary union.

It seemed of significance that Dr. Alexander O. Gettler, Pathological Chemist to Bellevue Hospital, had found that the chinosol-salt solutions precipitated only a negligible amount of the albumen present in blood serum.

The principles of the first-aid technic, for wounds which came early for disinfection, seemed to be, first, to remove the thin coagulum which forms on the surface of the wound, by wiping the wound with gauze saturated with the first-aid solution (a solution containing 2 per cent. of chinosol and reagent sodium chloride grains 4.1- $\frac{3}{4}$ or 0.85 per cent.), so as to unstop as much as possible the open mouths of the wounded lymphatics, then to fill the wound,

if it could retain fluid, with the first-aid solution in order to encourage the latter to infiltrate the nearby lymphatics, and, in any case, to sop the wound freely with the solution, applied by means of gauze, with a view of attaining the same purpose. Then, *if the wound were capable of repair*, (1) it might be repaired at once, and closed without drainage, with the expectation of getting primary union, or, (2) it might be packed with gauze saturated with the solution, which should be covered with impervious material, and which could be left in place before repair of the wound was done, for at least as long as fifteen to eighteen hours if necessary, or probably for a good deal longer. In either instance the first-aid solution should be used freely in the wound during the operation for repair, and the wound closed without drainage. If the effectual action of chinisol in wound disinfection were due to its stimulation of phagocytosis, as seemed likely, since *in vitro* chinisol was but little bactericidal, drainage would only impede this physiological process. *If the wound were not capable of repair*, it should be treated open, being filled with gauze saturated with the first-aid chinisol-sodium chloride solution, which dressing might be removed once a day, or, if the gauze became adherent, then after a longer interval.

In the case of traumatic wounds widely contaminated with foreign material, as wounds of war, *which came late for first-aid disinfection*, at a time when the implanted bacteria had begun to multiply, it seemed to be a question whether it would be desirable to attempt more than a mechanical cleansing of the wound, and packing of the same with gauze saturated with the first-aid chinisol-sodium chloride solution, omitting any attempt to infiltrate the lymphatics with the latter, lest the attainment of such purpose might then become a means of spreading the infection, as had occurred in a number of freshly made experimental wound pockets in dogs, in which the scientific infection had preceded the infiltration of the lymphatics with the disinfectant solutions, suppuration which extended to a distance from the original wound having frequently resulted.

CASE I.—W. J. McI., aged twenty-eight. *Incised wound of nose and cheek.* Admitted to Bellevue Hospital December 12, 1920. The incision cut obliquely through the left nostril, passing in the median line just above the tip of the nose, entering the right nostril and completely severing the nasal septum, then, cutting through the junction of the right ala with the cheek, it passed backward and a little downward across the right cheek for a distance of about four inches, at which latter situation it was about three-quarters inch deep. There had been free hemorrhage into the wound from a severed facial artery. There was no evidence of iodine having been used. On admission, after arresting the hemorrhage and wiping the skin with the solution of Dr. Ellice McDonald (alcohol sixty parts, acetone forty parts, to which mixture 2 per cent. of pyxol is added) [McDonald, Ellice: *Journ. Amer. Med. Assn.*, February 7, 1915, vol. lxiv, p. 505, and *Surgery, Gynecology and*

Obstetrics, July, 1915, pp. 82-86], the solution of 2 per cent. chinisol and sodium chloride, grs. 4.1-5i, was poured into the wounds, which were then packed with gauze, saturated with the same solution, and this dressing was covered with rubber tissue.

Nine hours later the wound was examined and redressed as before, and one hour afterward was repaired. The tissues of the wound had preserved a perfectly fresh appearance and showed no chinisol staining. (The first-aid solution may combine with infiltrated blood to produce a gray or black stain of the tissues, which does not interfere with primary healing in a sterile wound.) Skin preparation was first by wiping with peroxide of hydrogen and then with ether to remove the blood clots, etc., then, for disinfection, by wiping with McDonald's solution. The wounds were wiped and sopped with the first-aid chinisol-sodium chloride solution, and the latter was poured into the wound of the cheek and used freely in the wounds during the operation for repair. Three deep catgut sutures approximated the fat of the cheek, while the skin was sutured with horse-hair. The sutures in the nose, which were deeply placed, did not bring the skin edges evenly together. The nostrils were packed with gauze wet with the first-aid solution and the stitch-line was covered with the same dressing, having rubber tissue superimposed. The wounds were dressed daily as above. The highest temperature following operation was 100 degrees. A primary swelling of the cheek reduced rapidly (fourth day). With the exception of two slight openings in the suture line of the cheek wound, from which a few drops of serum discharged on the second, third and fourth days, and a little ulceration along three or four stitches in the same wound, which were mere tacks in the skin edges, primary union took place throughout. The ragged line of union in the nose under the wet dressing with the first-aid solution, applied once daily, rapidly cicatrized and skinned over. The patient was discharged from the hospital on the eighth day, he returning for a few more dressings of the wound of the nose.

CASE II.—J. B., age twenty-four. *Incised wounds of neck, pinna and face.* Admitted to Bellevue Hospital December 27, 1920. Transverse incised wound of back of neck, about one inch below level of occiput and about four and a half inches long, extending from just behind the right ear to the left of the median line, cutting across the ligamentum nuchæ and completely through the adjoining one and a half inches of the right trapezius muscle. Also, in the same line, the right pinna was entirely cut through and there was a superficial incised wound of the right cheek about one and a half inches long. No iodine or other chemical had been used in the wounds prior to admission. A nicked occipital artery had bled freely into the wound. Though the skin around the wound had been wiped early with McDonald's solution, the hair of the scalp was not shaved until just before the operation. The wounds were washed with the solution of 2 per cent. chinisol and sodium chloride, grs. 4.1-5i, and then packed with gauze saturated with the same solution. Twelve hours later the wounds were examined. That of the neck was filled with the first-aid solution and all the wounds

were repacked with gauze saturated with the same solution; overlapping the skin edges.

Operation for repair thirty-one hours after the first-aid solution had first been used in the wounds. The wounded tissues at this time were fresh and moist and normal in color, and without a particle of chinosol staining. The skin was cleansed of its blood stains by wiping with peroxide of hydrogen and afterward with ether, was shaved and then disinfected with McDonald's solution. The first-aid chinosol-sodium-chloride solution was used freely in the wounds. The wound of the trapezius was sutured with interrupted chromic sutures, the skin of the neck with silkworm gut and the wounds of the ear and face with horse-hair. The wounds were dressed with gauze wet with the first-aid solution, which was covered with rubber tissue. Uneventful recovery. Primary union throughout.

CASE III.—T. L. O'D. Electrician. Age about twenty-two. This case illustrates the open first-aid treatment of wounds unsuitable for primary repair. It was one of *high compound fracture of the leg with gangrene of the foot*, in which suppuration did not occur in the wound, treated open with the first-aid chinosol-sodium chloride solution then in use (chinosol, grs. iv- $\bar{3}$ i, and normal sodium chloride), so that it was possible on the fifth day to amputate at the seat of fracture and ultimately to save the knee-joint.

On March 12, 1919, the patient was admitted to Bellevue Hospital after having sustained a compound fracture of the left leg about four inches below the knee-joint, with much laceration of the soft parts, there having been a widely separated wound anteriorly, and the finger passed backward between the bony fragments, entering an area of deep laceration behind the seat of fracture. The foot was lifeless. There had been no iodine or other chemical introduced into this wound prior to the first-aid dressing with gauze saturated with a solution of chinosol, grs. iv- $\bar{3}$ i, and 0.85 per cent. sodium chloride, the first-aid solution in use at that time, which was laid in the interior of the entire lacerated area, having been introduced through the seat of fracture, into the wounded soft parts behind. Two strips of gauze, introduced at the first dressing, became so tightly adherent in the deep wound that they could not be readily detached until the fourth day. When removed they were odorless. The wound was dressed once daily. On the second day, all the gauze that was detachable was removed, the wound cavity was filled with the first-aid solution and fresh gauze wet with the latter was introduced. On the third day, all loose pieces of gauze were removed. Some of the gauze applied to the superficial wound on the preceding day had become adherent. The gauze withdrawn was perfectly sweet and there was no pus in the wound. The deep wound was now filled with the first-aid solution and gauze wet with the latter was simply laid over the superficial wound and was covered with rubber tissue. The temperature was not over 100.4° until the fourth day, when it rose to 102°. On the fifth day amputation of the leg was performed, which was done through the seat of fracture, making a long

posterior flap, including muscle which was the seat of thrombi, though the posterior tibial artery in the flap pulsed. A personal note on the operation stated: "The wound contained a little serosanguinolent discharge." Following the amputation, the interior of the wound sloughed, and to facilitate the removal of the sloughs, gauze saturated with a solution of 2 per cent. chinisol and 5 per cent. sodium chloride, was applied to the wound once daily. (Caution was recommended in the use of the latter strongly hypertonic solution on tissues affected by senile or trophic changes.) On the eleventh day post-operative, a slough of the calf muscle, half the size of a fist, had almost separated and was removed by cutting a few remaining attachments. On the fourteenth day, after finally washing the wound, which was now practically free from sloughs, with the same solution, the posterior skin flap was laid forward against the granulating surface behind the tibia and a compress applied, and on the following day the apposed tissues had adhered nearly everywhere. The tibial fragment protruded.

On April 23rd reamputation was performed, the line of dividing the bones being through the lower portion of the tubercle of the tibia and through the middle of the head of the fibula. A solution of 2 per cent. chinisol and 0.85 per cent. sodium chloride was used in the wound during the operation. The wound was closed with drainage and primary union occurred in all of the apposed tissues and the drain sinuses rapidly closed. The middle of August, 1919, the patient began wearing an artificial leg. Three months later he stated that his artificial leg had never given him any trouble, that his stump had never swelled and that he was on his feet all day long. Since then the patient has had no trouble, climbing ladders with ease in the routine of his work.

DOCTOR LUSK said that he believed this open first-aid treatment would be applicable as well to the *wounds of war*, in which a gauze packing, saturated with the first-aid solution (2 per cent. chinisol and sodium chloride, grs. 4.1-5i), and covered with impervious material, at least could be expected to arrest bacterial growth and prevent decomposition for a considerable period of time.

The first-aid solution was made with *cold* sterile distilled water, in which 2 per cent. of chinisol powder should first be dissolved, and then *reagent* sodium chloride, grs. 4.1 to the ounce (0.85 per cent.), which should be added in bulk. In making up this solution the glass receptacles and utensils should first be scoured with neutral sodium oleate and then boiled in plain water. An alkali would precipitate oxyquinolin from the chinisol (oxyquinolin sulphate), so that soda should not be put into the water used for boiling. A glass vessel was preferable to an enamelled one as a container, since spots of bare iron usually present in the latter receptacle, would discolor the chinisol.

The addition of the sodium chloride to the chinisol in solution, changed the microscopic picture of the crystallization of the chinisol and was believed

to render the latter little liable to irritate. A solution of 2 per cent. chinol in combination with normal sodium chloride had seemed liable to irritate only from too oft repeated applications daily, or from a too long-continued use of the applications once daily on gauze left *in situ* between dressings, in the latter instance the skin alone being usually affected, the wound apparently being protected by dilution of the solution with a sufficient amount of secretion. The solution on first coming into contact with a wound caused a burning sensation for a few moments. The "reagent" sodium chloride had seemed to produce more completely the changes in the crystallization of the chinol than had less pure varieties of sodium chloride. Boiling of the sodium chloride had seemed to produce salt cubes, as seen under the microscope in the crystallized specimen, generally larger in size and fewer in number than when the sodium chloride was added to the solution without boiling, the finer subdivision of the cubes of the unboiled product apparently acting more widely throughout the solution to cause the change in the crystallization of the chinol. The chinol-salt solutions should not be boiled, since when boiled they caused a greatly intensified burning sensation in the wounds and had seemed liable to produce a superficial tissue necrosis.

Grains xxiv of chinol in solution had been infiltrated into the lymphatics around a sterile subcutaneous wound pocket, free from blood infiltration, in the back of a dog weighing 8 kilos, with primary union in the sutured wound and without subsequent ill effects.

DR. ROBERT T. MORRIS asked Doctor Lusk whether the use of the isotonic saline solution allowed him to use a stronger chinol solution without causing irritation than would be possible otherwise. He stated that he used chinol solution in about the same proportion as bichloride of mercury. Used in that way, he found that a 2 per cent. solution of chinol was sometimes irritating, and he had depended chiefly upon less than 1 per cent. in solution without salt. It was one of the best antiseptics for all around convenience.

DOCTOR LUSK, in answer to Doctor Morris' question, said he believed that the addition of the sodium chloride in normal strength to a solution of 2 per cent. chinol, which changed the form of crystallization of the latter, made the solution of this strength of chinol less liable to cause irritation. In the first-aid treatment of fresh traumatic wounds as described, the speaker had seen no evidence of chinol irritation. Where sterilization of abscess cavities was sought by the daily introduction into them of a gauze packing saturated with the first-aid solution, left in place between daily dressings, wound or skin irritation had not been seen. In general terms, a sufficient amount of wound secretion had seemed to be protective against the production of wound or skin irritation as a result of the application of the solution of 2 per cent. chinol and normal sodium chloride on gauze left in place between daily dressings, and where the wound secretion was ample, it had seemed that this wet dressing could, as well, be confined beneath an imperious covering with impunity. In the case of small wounds without much secretion, an external dressing saturated with the first-aid solution, renewed

once a day, night, after a little while, irritate the skin, it being particularly liable to do so when confined beneath an impervious covering, which latter should generally not be used on these cases. At the same time, a first-aid wet dressing applied once a day to an illy-apposed suture line, had, in a number of instances, caused rapid healing of the ragged edges. But two wounds, ones of long standing, had seemed to have become irritated from the application of the first-aid solution once daily, to one of them (thrombo-angiitis) the application having been made for only a short period of time each day, in the other, the packing wet with the solution having been retained between daily dressings over a considerable period of time, and each discharging but little secretion. Granulating wounds with but little secretion had sometimes been syringed with normal saline before packing them with gauze wet with the first-aid solution, which technic had seemed to be favorable to healing.

To Test Effect of the Reaction of Chinosol with Iron in a Fresh Wound.
(Dog No. 154.) Two sterile subcutaneous wound pockets, one with, and the other without, blood infiltration, whose open lymphatics were infiltrated with solution of Chinosol grains IV = one ounce and 0.85% sodium chloride, several ounces of which solution four iron nails, 2½ inches long, had lain for 4 days, discoloring the same, were both blackened, and, following primary suture, both healed by primary union.

(Dog No. 159.) Two sterile subcutaneous wound pockets without blood infiltration, in each of which a sterile nail had been laid before suturing, and which, 24 hrs. after their closure, were reopened and, following removal of the nails, were soaked with a solution of Chinosol grains VI = one ounce and 0.85% sodium chloride and then packed for a short time with gauze wet with the same solution, which latter stained the nail-beds black, and were finally resutured, united primarily.

RECOVERY OF A NEEDLE FROM TENDON OF FLEXOR LONGUS HALLUCIS.*

BY W. HOWARD BARBER, M.D.,
NEW YORK.

THE patient, E. G., a young woman 25 years of age, gives a history of having driven a needle into the heel of the left foot while bathing ten years ago. The exacerbation of pain during the past few days on walking led her to believe she might have injured her foot again. Physical signs are negative excepting for tenderness over the left plantar arch. Stereoscopic and other x-rays represented the needle buried in the plantar fascia and lying parallel to the first metatarsal bone. An incision was made in line with the needle, the foreign body was recovered, and the wound was closed, all within five minutes. The operation revealed a rusted needle 3 cm. long, impacted within the tendon of the flexor longus hallucis muscle and underlying the shaft of the first metatarsal bone. The stiffness of the tendon, as though calcified, drew attention to the possibility of the foreign body being within it. The tendon was split before the needle was exposed sufficiently to with-

*From the Department of Surgery, New York University and Bellevue Hospital Medical College.

draw it. The instructive factors in this experience are:

1. The progression of the needle within the tendinous fibers of the long flexor of the great toe.



Roentgenogram of E. G. with tendon of flexor longus hallucis sketched in to illustrate the site of the needle lying completely imbedded within the tendon ten years after entry into the patient's heel. (Case referred by Dr. J. Kelly of Scranton.)

2. The sudden appearance of pain ten years after entry.

3. The value of stereoscopic pictures for pre-operative study and the importance of antero-

posterior and lateral views for localization at the time of operation.

4. The importance of searching aponeuroses and tendons in the long-standing cases of foreign bodies in the extremities.

616 MADISON AVENUE.

ADMINISTRATION OF ETHER BY THE USE OF A SIMPLE MECHANICAL ETHER DROPPER *

CONSTANTINE L. A. ODÉN, MS., M.D.

CHICAGO

AND

ALEXANDER FOSHEE, M.D.

NEW YORK

The open method of etherization was originated and developed in 1893 by Dr. Lawrence Prince. Isabella Herb was associated with Dr. Prince, and in 1888 she reported 1,000 cases in which she gave the open method. She relates that the superiority of this method is evidenced by a steady growth in popularity. According to the statistics of the committee on anesthesia of the American Medical Association, more than half of the ether anesthesia administered from 1905 to 1912 were by the open method. The simplicity of this method should argue rather for than against its efficiency.

TECHNIC OF OPEN ETHER ADMINISTRATION

The administration of ether spells comfort or discomfort to the patient. Often it establishes his attitude toward ether, and determines the patient's reaction toward the whole art of surgery. Many hospitals are not equipped for the induction of gas and oxygen, which doubtless is most agreeable to the patient, and must resort to ether alone, which has been found the most desirable method. By gaining the patient's confidence and telling her to breathe naturally, allowing her at first barely to smell the ether, and then gradually increasing the drop, we have no trouble to induce narcosis. Rarely do we experience any excitement stage. Occasionally a volatile oil, such as oil of lavender, is placed on the mask, which disguises the odor of the ether, and the patient loses consciousness before the ether becomes too concentrated. A gauze ring pad is placed over the face before the anesthetic is started; this keeps the air from passing in except through the cone. The cover on the cone should not be too thick. From four to six

*Read before the gynecologic conference at Bellevue Hospital, Dec. 3, 1921.

*From the Post-Graduate Department of Surgery, University and Bellevue Hospital Medical College, New York.

layers of gauze are ample; if more are used, this method becomes semiclosed. A stockinet is much better for covering the mask than is gauze. If the cone is too thin, it is difficult or impossible to induce and maintain anesthesia. The ether should be dropped continuously on the cone. If the dropping is suspended until the patient becomes rigid, then this becomes an uneven narcosis. Intermittent administration of ether has the further disadvantage or danger of administering too concentrated a vapor in one's haste to get the patient in under again. It has been proved that from 6 to 7 per cent. ether



Apparatus for administering ether, attached to operating table.

vapor is the greatest concentration which can be inhaled without irritation to the air passages. When the proper technic of etherization is carried out by a steady, even drop, which can best be done by the use of a mechanical apparatus as described below, narcosis develops along the lines of a natural sleep. It is rare not to have a smooth anesthesia, with relaxed muscles and perfect oxygenation.

The open drop method is suitable for any operation in which ether is the anesthetic of choice. Trouble during induction is due to faulty technic or poor ether.

ADVANTAGES OF THE OPEN METHOD

This rests on demonstrated facts. The greatest advantage of this method is the large and constant supply of oxygen that the patient receives during the anesthesia, which is indicated by the good color of the skin and blood. There should be no toxic effects. Gatch,¹ in 1911, during a series of experiments, proved that the severity of pulmonary lesions found after experimental etherization by the closed method is accounted for by the great concentration of the ether vapor.

Dresser,² in 1895, showed that ether vapor in the closed mask often rose to a concentration of 34 per cent., while 6 or 7 per cent. is the strongest concentration that can be inhaled without irritation to the air passages. He regards any concentration of ether which cannot be inhaled by the conscious person without coughing as harmful to the lung epithelium.

Offergeld,³ in 1898, studied pathologic changes in the lungs after etherization of a series of animals for from seventy to eighty minutes by the closed method. The open method was given to another series of animals. Many of the animals etherized by the closed method died of bronchopneumonia; the rest were killed, and all were found to have patches of consolidation, desquamation and hemorrhages into the alveoli. None of the animals anesthetized by the open method died. After two days there were no changes in the lungs at necropsy, while the closed method victims showed pathologic changes four days after etherization.

As mentioned in a previous paragraph, a perfectly smooth, even drop can best be given by the use of a mechanical dropper. Various ether droppers have been made for this purpose, but many of these have been unsatisfactory; for this reason we have devised an apparatus, which in every way meets the necessary requirements. It has proved that narcosis can be produced without any excitement stage. The pulse and respiration remain good, the color of the patient is excellent, and the postoperative blood pressure in many cases exceeds the preoperative pressure.

The apparatus is very simple, but is efficient when properly handled. It consists of a transparent glass cup through which runs a needle valve that regulates the drop. The cup holds one 4 ounce can of ether. This cup is suspended on a flexible arm which is fastened to a clamp, and can be attached to any operating room table with ease. The flexible arm allows the cup to be placed at any desired angle.

The advantages of this apparatus are: that it is easy to manipulate; it gives an even, steady drop on one place of the

1. Gatch, W. D.: The Use of Rebreathing in the Administration of Anesthetics, *J. A. M. A.* **57**: 1593 (Nov. 11) 1911.

2. Dresser: *Bull. Johns Hopkins Hosp.* **6**: 7, 1895.

3. Offergeld: *Arch. f. klin. Chir.* **57**: 175, 1898.

cone; it allows perfect oxygenation with smooth anesthesia; induction is readily and easily produced with it; it leaves one hand free so that the anesthetist may attend his patient with ease, and it can readily be attached to any operating table.

CONCLUSIONS

With the open method of etherization, the blood is well oxygenated. The concentration of the ether is small. There is no rebreathing, but always a fresh supply of air. There is less injury to the lung epithelium. Anesthesia is easily induced, and a simple mechanical apparatus is best for obtaining a smooth, even drop.

The apparatus described was made by the Foregger Company, Inc., 47 West Forty-Second Street, New York.

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A bandage that will stay in place and still be comfortable when applied to the thorax is especially desirable in surgical conditions of the chest, breast, back and allied areas. The one described herein has been demonstrated to possess all of these qualities. After searching the literature at my command, and finding no similar bandage for this region described, I venture to present it.

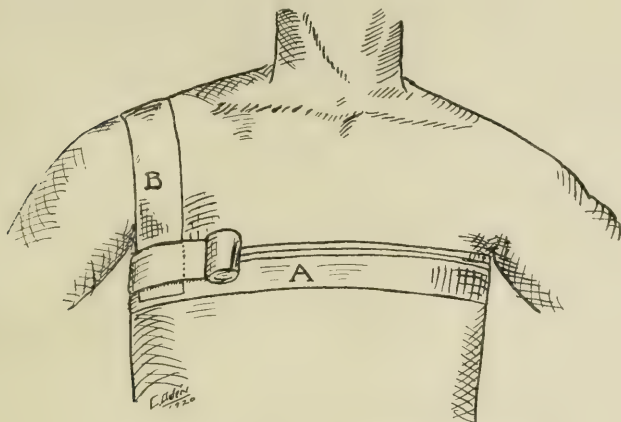


Fig. 1.—Method of applying bandage to thorax.

Two 3-inch gauze bandages are used. With one bandage (Fig. 1 *A*), three circular turns are made horizontally around the chest to a point at the pectoral region where the end of the second bandage, *B*, is caught in its fold. This bandage, *B*, is then carried up over the shoulder and down to the scapular region, where it is again caught by a circular turn of *A*. This process is continued until the desired area is covered (Fig. 2).

In case it is desired to cover both scapulopectoral areas, a third bandage can be applied simultaneously like *B* on the opposite shoulder. The folds of these bandages *B* and *C* are caught and held with the same circular turns of *A*. In this manner the entire chest and both shoulders can be covered at one time, a factor often desirable.

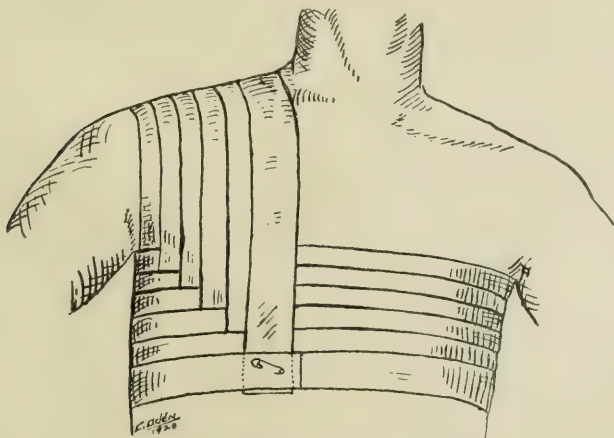


Fig. 2.—Bandage covering desired area.

This bandage has a distinct advantage over any other used for a similar purpose. It will not work loose, but will stay in place until taken off. As stated, it is especially useful, and fills a long felt want where large areas are to be covered and

A Modification of the Odén Band- age for the Thorax

EDWARD M. LIVINGSTON, M.D.
NEW YORK

A MODIFICATION OF THE ODÉN BANDAGE FOR THE THORAX

EDWARD M. LIVINGSTON, M.D.
NEW YORK

The Odén¹ bandage for the thorax (Fig. 1) is a bandage of marked superiority over the usual combination of bandages used to cover the shoulders and thorax. The originator employed it merely as a bandage of the thorax, the vertical turns acting as slings or supports to insure additional security.² The shoulder portion, however, is quite as useful as the thoracic; and as well as possessing the virtues originally claimed for it, the bandage proves ideal for retaining dressings to both shoulder and chest, in extensive burns, after removal of tumors, etc. In extending the application of the bandage to these cases, three main objections might be made: 1. The vertical turns do not fit well on the shoulders. 2. There is a tendency for the vertical turns to slip over the shoulder tip. 3. Dressings in the infraclavicular fossae and suprascapular regions tend to slip from beneath the loose vertical turns of the bandage.

To obviate these faults, the following modifications are suggested: (a) That the shoulder portion be made with oblique rather than vertical turns, as a dressmaker would fit a collar, that the normal obliquity of the shoulders may be met. (b) After completing the turns of the original bandage, one should continue with the first roller, the horizontal roller, to form a figure of eight over the affected shoulder and through the opposite axilla, this second modification preventing the bandage from slipping over the shoulder tip and likewise making pressure in the infraclavicular and suprascapular regions.

The accompanying sketches illustrate these modifications of the bandage which might, therefore, be thus applied:

1. The first roller is begun with its initial extremity over the junction of the manubrium with the body of the sternum. A horizontal turn or two around the thorax at this level fixes the bandage.

2. The second roller is started at the same point, but is directed upward to the base of the neck on the affected side;

1. Odén, C. L. A.: A Practical Bandage for the Thorax, J. A. M. A. **76**: 174 (Jan. 15) 1921.

2. Personal communication from the originator.

over the shoulder; and down the back obliquely to a point opposite the starting point. The bandage is here caught by the next horizontal turn of the first roller (like a recurrent bandage of the head).

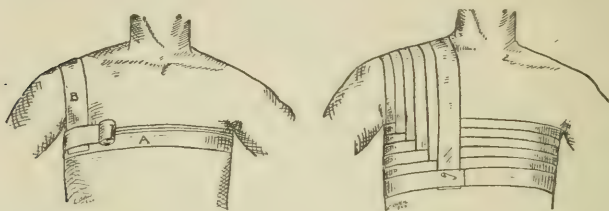


Fig. 1.—Odén bandage: at left, method of applying; at right, bandage covering desired area.

3. The procedure is continued in this fashion, descending horizontal turns being made with the first roller, catching turns of the second roller, both anteriorly and posteriorly, as the shoulder is being covered. One should progress toward the tip of the shoulder with the roller number two, overlapping previous turns by one half.

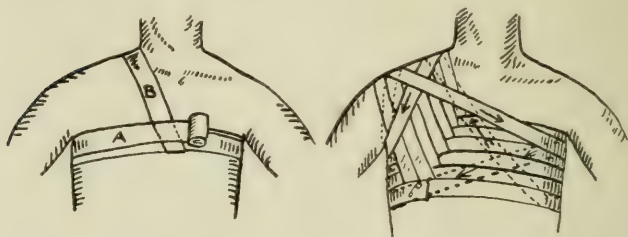


Fig. 2.—Modification of Odén bandage: at left, method of applying; at right, bandage covering desired area.

4. When the desired portions of both the thorax and the shoulder are covered, the first roller is continued obliquely across the back; up over the affected shoulder; into the affected axilla; back up over the affected shoulder; across the chest into the unaffected axilla, and obliquely downward across the back, where the bandage is terminated by pinning; i. e., a figure of eight is superimposed upon the original bandage, the first roller being utilized for this purpose.

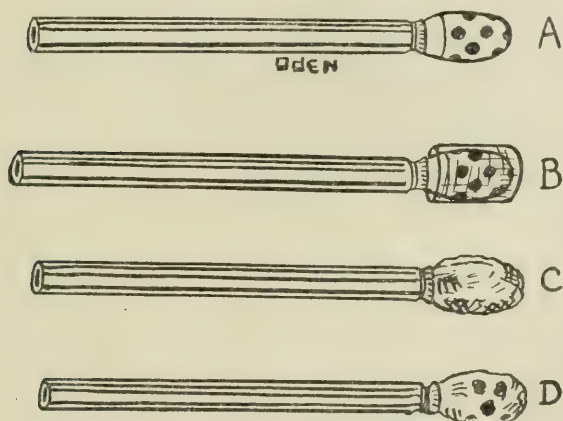
5. If it is desired also to cover the second shoulder, similar recurrent turns may be made with a third roller, or the second roller may be utilized, a V being formed both anteriorly and posteriorly.

172 Lexington Avenue.

A METHOD FOR SEALING THE DISTAL END OF THE EINHORN INTESTINAL TUBE

CONSTANTINE L. A. ODÉN, M.S., M.D.
NEW YORK

During the course of an investigation of the bacterial flora of the intestine at different levels,¹ Dr. Aaronovitch found that the intestinal tube rapidly became contaminated after its introduction into the alimentary tract. Under these circumstances it was impossible to determine with any degree of certainty the characters of the flora at the levels reached by the tube. Various procedures for sealing the distal end of the tube, such as coating the olive with a layer of rubber or



A, olive at end of tube (actual size of olive); B, gelatin capsule covering the olive; C, parresine covering; D, olive when parresine coating has been perforated.

paraffin, were tried but were found unsatisfactory. To fulfil the conditions of the investigation it was necessary not only to seal the end of the tube but also to have the seal under perfect control, that is, so that it may be broken at any desired level.

The following procedure was finally adopted and found satisfactory: The tube is sterilized thoroughly before the sealing; this is best done in a steam sterilizer. After steril-

1. This investigation is being carried out under the direction of Drs. Warren Coleman and Max Einhorn.

ization the water is drained, and the olive (*A* in the accompanying illustration) is heated over a Bunsen flame to make sure that no organisms remain on the outer side, also to dry it. The large end of a gelatin capsule is placed over the olive and must fit snugly, as its purpose is to act as a base for the parresine which is to be sprayed over it by using a spraying apparatus such as is used in the treatment of burns (*B* and *C*).

Care must be taken that not too thick a layer of parresine is sprayed over the capsule, as it will be difficult to perforate. We have found that about 1 mm. thickness of parresine is sufficient to protect the olive from the intestinal contents. Paraffin may be used as well as parresine, but the latter is preferable as it is softer and easier to perforate at the body temperature. The capsule is sterile, being kept in 85 per cent. alcohol at least twenty-four hours before using. This has been proved by the taking of repeated cultures. The parresine and the spraying apparatus are sterilized.

Although the tube is drained of the water which remains after sterilization, there remains enough moisture within it to dissolve the gelatin capsule, and this leaves only the parresine coating, which will stay on indefinitely until perforated (*D*). To perforate, all that is necessary is to force air into the tube by a previously sterilized syringe, the same syringe being used for the withdrawal of the contents. The patient does not complain of any discomfort during this operation.

Bellevue Hospital, Twenty-Sixth Street and First Avenue.

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